Ph. D. Dissertation in Economics

Nature versus Nurture in Resources and Capabilities on the Firm Growth

- An Empirical Study of the firm growth -

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Abstract

Nature versus Nurture in Resources and Capabilities on the Firm Growth

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The present research seeks to clarify factors affecting firm growth with regard to resources and capabilities (R&Cs). Specifically, this thesis focuses on two classes of R&Cs that influence firms' growth prospects: pre-entry R&Cs and post-entry R&Cs. The relationship between the state of firms upon market entry and the future growth of firms is also analyzed.

This study divides the R&Cs that are crucial to a new firm's growth into two categories analogous to the concepts of nature and nurture in human developmental studies: (1) inherited "natural" R&Cs that are present before the firm's market entry and (2) cultivated, "nurtured" ones that are acquired after the entry. The study seeks to verify whether and to what extent each has an effect on the long-term growth of the firm. This nature/nurture approach is considered and elaborated in a literature review of selected theories and related empirical findings, which are integrated to derive a novel

methodology for the analysis of growth-affecting factors through time for new market entrants. This is applied in two research efforts.

The first research element (Chapter Four) is focused on the effect of pre-entry experience. The aim of the first research element is to examine whether *de alio* or *de novo* firms achieve faster sales growth, and how long the effects of these respective entrance conditions persist, when they enter the new and renewable energy industry. Firms that have just entered new markets can be distinguished as either those with pre-entry experience in other areas (*de alio*), or those without such pre-entry experience (*de novo*). *De alio* firms tend to enter markets under conditions that are advantageous in light of their pre-entry experience; on the other hand, *de novo* firms tend to enter markets with innovation capabilities. Therefore, this study identifies and compares growth patterns of *de alio* and *de novo* firms over a period following market entry. This is undertaken by means of panel data for global companies that entered the new and renewable energy industry after the 1990s.

The results show that *de alio* firms achieved higher growth rates than *de novo* firms in the initial stages following entrance but that the entry type's contribution to sales growth gradually decreased, disappearing within four years after entrance. The results indicate that previously accumulated resources and new entrants' former experiences in other industries have positive effects, helping them achieve initial success (for a limited time) after entry into an industry. This suggests that firms adapt the R&Cs that are appropriate for their new environments derived from pre-entry experience for the sake of sustainable development.

The aim of the second research element (Chapter Five) is to compare the effects of pre-entry experience and post-entry effort. Findings demonstrate that nurtured (i.e., post-entry) R&Cs affect a firm's growth rate more than inherited/natural (i.e., originating pre-entry) R&Cs do. The results of the empirical analysis demonstrate that pre-entry experience and post-entry effort have various impacts on the growth of firms. This research provides important clues in understanding whether the R&Cs that lead to growth of firms are from the pre-entry or post-entry effort.

The positive impact of natural R&Cs diminishes as time goes by, which indicates that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate. In other words, natural R&Cs can be effective on short-term results, but as time goes by and environmental changes occur, the firms dependent only on inherited R&Cs do not eventually adapt to these changes, and consequently tend to generate insufficient result in the long-term.

On the other hand, nurtured R&Cs do not lose their validity and have long-term positive effects on the firm, which indicates that post-entry effort influences both short-term and (to a an increasing extent) long-term growth rates.

Depending on the type of efforts, the post-entry efforts show different impacts on short and long-term results. Some are more favorable for short-term performance but unfavorable for long-term performance, and vice versa. Most R&D activities are unfavorable for short-term performance but favorable for long-term performance.

However, the efforts for increasing human resources, for example, have the opposite effect.

In high-tech industries, the discrepancy of this effect is obvious, because natural R&Cs gained from pre-entry experience are likely to be unsuited to the market or the competing environment. Conversely, nurtured R&Cs (by post-entry effort) are likely to be well-suited to the evolving market environment, competitors' trends, and firms' situations.

The results of the research indicate that firms' management executives, when considering pre-entry experience and post-entry effort in strategizing and forecasting growth, should focus on establishing and maintaining good structural inertia more than increasing organizational size.

In addition, the findings can inform the decision-making processes of policy-makers. Since the incubation period, when firms can conduct trial and error-based development, is very important, government support should be designed to augment the future growth of firms by facilitating effective post-entry effort.

Key words: pre-entry experience, post-entry effort, firm growth, resources and capabilities, *de alio* and *de novo*

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Chapter 1. Introduction

"The firms that have differentiated R&Cs can grow, but only the firms that pursue the continuous growth can survive." This statement is widely accepted by management theorists. It is widely accepted; however, that does not mean that all the firms can grow and survive. Thus, knowing the effects of differentiated R&Cs is important. However, an understanding of how effective R&Cs can be secured and evolved is necessary to achieve success. To implement an effective strategy, it is essential to comprehend the origins R&Cs. In other words, it is necessary to understand the extent to which the present and future growth of firms depend on the inherited (natural) R&Cs or nurtured R&Cs.

The research studies new market entrants in light of the origins of those R&Cs. The research compares the inherited R&Cs received through pre-entry experience and the nurtured R&Cs gained through post-entry effort. The overall aim is to determine how, to what extent, and over what timeframe each type of R&Cs affects firms' growth.

The theoretical frameworks that the research uses are organization ecology, evolutionary economics, and the resources-based view. This research combines these core theories and analyzes the growth patterns of the newly established firms from this integrated theoretical perspective. Recent research has sought to explain the inception and growth of firms from the combined viewpoint considering selection of organization ecology and adaptation of evolutionary economics (Fortune & Mitchell, 2012); in addition, the resources-based view is a key perspective of evolutionary theory in research on dynamic R&Cs (Fortune & Mitchell, 2012; Helfat, 2007; Helfat & Peteraf, 2003). The convergence of these three viewpoints presents a viable framework for connecting the inherited and nurtured characteristics of the R&Cs to the growth of firms.

There are three core reasons for selecting newly established firms as the research subject. First, inherited R&Cs coexist with nurtured R&Cs in the early stages following market entry. Second, the establishment of a firm provides a fixed point to delineate pre-entry experience and post-entry effort, which facilitates the interpretation of R&Cs in the perspective of “nature and nurture.” Third, because the post-entry effort does not have many types, the actual forms of the nurtured R&Cs can be clearly defined.

The nature vs. nurture debate in the field of human development has a long history. Until recently, it was considered to provide a clear insight into the triggers for the human behavior. Likewise, when we see consider R&Cs in their impact on the growth of firms through the lens of nature and nurture, management and policy-makers can gain valuable insight regarding executable and detailed solutions concerning firm growth.

The present research intends to clarify the nature and nurture perspective on R&Cs, facilitating an examination of the relationship between the initial state of the firm and the future growth of the firms by conducting an empirical study of inherited and nurtured R&Cs and their influence on the future growth of firms.

1.1 Motivation, research objectives, and approach of the thesis

1.1.1 New perspectives on firm growth

What types of firms can sustain growth? This is a question of keen interest to many scholars, entrepreneurs, and policy-makers. Systematic research into the growth of firms is widely considered to have begun with Edith Penrose's (1959) *Theory of the Growth of the Firm*, and has continued vigorously to present. The environment surrounding firms continues to demand changes, and those firms succeeding in making those changes survive, while those that do not are removed, further changing the environment. In this cycle, the R&Cs of the firms with strong survival power are reinforced; nevertheless, with the evolution of the business environment, competition threatens stability, and inception, growth, and decline of firms are ongoing. Thus, environment, firms, and R&Cs evolve continuously. As the market environment becomes more complex and uncertain, the factors affecting firms' growth become increasingly diverse and complex.

A firm's future growth is typically determined by how innovative the firm can be, how responsive the firm can be to the environmental change, and how differentiated and competitive the firm's internal capabilities (developed through experience or strategic efforts) are compared to other firms. Unfortunately, the previous study of firm growth focused on the firm's size and age, etc. Therefore, the present research intends to switch the focus from firm's size and age to the origins of the R&Cs, which are the basis of the growth of the firms, and analyze the causes of the growth of the firms in a macroscopic, multi-theoretical perspective, instead of the microscopic and detailed approach taken by existing research.

Focusing on nature vs. nurture in resources and capabilities

Can we predict the future of the firms other than by extrapolating from the size and age of the firm? In other words, can we understand the firm's growth in terms of firms' levels of experience and the nature of their strategies? This is the fundamental question of the research.

This question of whether the fundamental cause of human behavior is genetic or environmental is traditionally referred to as the debate over "nature and nurture." The reason why this long-standing debate between the nativists and empiricists is brought in is that it persists as a relevant analytical framework in various fields. It is a simple dichotomy; however, the research process to prove which side is more influential has provided clear insights and wisdom as to the understanding of human behavior. If firms' activities show similar patterns to human behavior (although the use of this perspective on firm growth may be controversial), then a novel understanding of the causes of firms' growth can emerge in the process of investigating such patterns.

As seen in Figure 1, newly established firms grow gradually through learning by doing with the pre-existing R&Cs, which are either inherited from the parent firms or developed in the course of the firms' activities. Therefore, in order to understand and predict the growth of firms, it is essential to observe how innate R&Cs are created and increased with the new firms' post-entry effort and how can these are linked to the future performance of the firms in more multi-dimensional and dynamic ways.

To comprehend the new firms in a multi-theoretical way, organization ecology (Hannan and Freeman, 1989), evolutionary economics (Nelson and Winter, 1982), and the dynamic resource-based view (Teece et al., 1997) are used in the present study. Organization ecology focuses on how the inherited R&Cs play roles in the environmental selection of firms (Hannan and Freeman, 1977, 1989). Evolutionary economics focuses on how the nurtured R&Cs are adapted in the interaction between firms and environments (Gort and Klepper, 1982; Nelson and Winter, 1982).

New firms have to be selected and adapt at the same time, as Fortune and Mitchell (2012) state; thus, the recently-emerged resource-based theory plays an essential role in combining organization ecology and evolutionary economics with the medium of R&Cs. Here "resources" are defined as the stocks, such as materials and human assets, that firms own or control, and the "capability" is manifested in the process of dealing with the resources effectively while responding to the environment (Amit and Schoemaker, 1993). In this perspective, evolutionary theory concerns how the differences of the firms' capabilities dictate success in response to the evolving environment (Huyghebaert and Van de Gucht, 2004; Mata and Portugal, 2002; Sarkar et al., 2006; Zúñiga-Vicente and Vicente-Lorente, 2006).

As a basis for the application of the nature/ nurture dichotomy in understanding how the process of new firms' securing R&Cs pre- and post-entry is connected to future performance, it is essential to delineate the combined theoretical framework clearly.

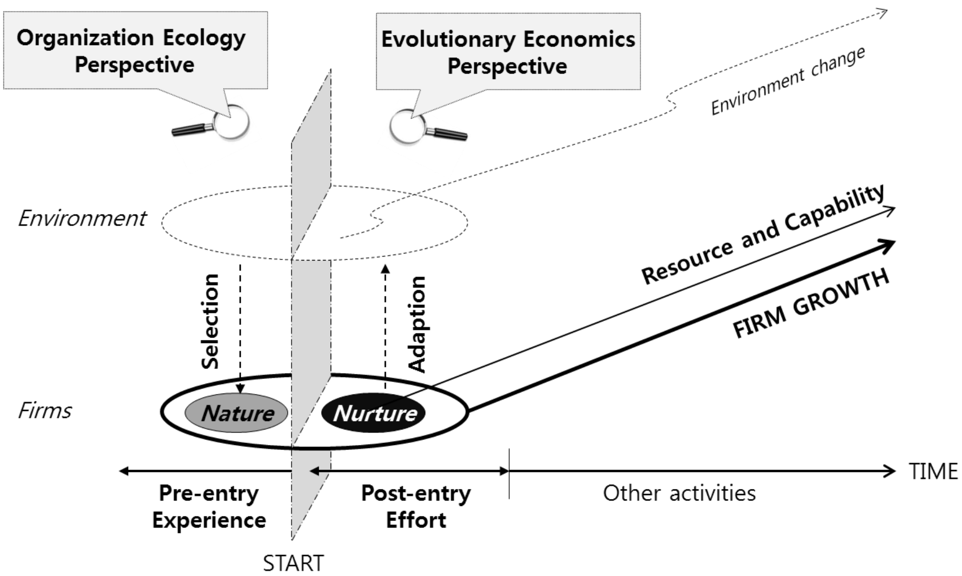

Figure 1. Conceptual diagram: Firm growth patterns and background issues

How to measure resources and capabilities from the nature/nurture perspective

Firms separated from parent firms have inherited R&Cs due to the pre-entry experience of the parent firm, and are thus categorized as *de alio*. On the other hand, start-ups or venture firms have no pre-entry experience, and thus typically have fewer R&Cs; these are categorized as *de novo* firms (Helfat and Lieberman, 2002). Research into the survival and extinction of *de alio* and *de novo* firms is helpful in understanding the influences of “natural” R&Cs on firms’ performance (Barnett et al., 2003; Carroll et al., 1996; Hannan et al., 1998; Hannan and Freeman, 1988; Khessina, 2003; Khessina and Carroll, 2008; Mitchell, 1994; Swanson, 2002).

On the other hand, nurtured R&Cs emerge differently depending on post-entry efforts. Efforts can be considered a proxy of firms' capabilities (Kogut and Zander, 1993; Teece et al., 1997; Zollo and Winter, 2002). Thus, firms accumulate capability through experiences or efforts.

R&Cs can be categorized as nature or nurture by delineating them as pre-entry experience and post-entry efforts, respectively. How these categories of R&Cs are connected to the future growth is analyzed in the present thesis. To see the long-term effects of inherited and nurtured R&Cs, the current thesis considers post-entry effort based on firms' efforts over a certain limited period of time following their establishment as among the capabilities accumulated through learning by doing.

On the firm-level, firms' R&Cs impacts on performance and competitive advantages have been researched in depth in the resource-based view (Barney, 1991; Peteraf, 1993). The resources-based view shows how firms combine and develop their R&Cs in the process of adaptation to the changing environment (Helfat and Peteraf, 2003).

The present research is based on the premise that the future growth of new firms depends on whether they enter the business with R&Cs sufficient to thrive in the new environment or actively increase R&Cs that can be adapted to the environment during the early stages of business development. Therefore, the present research focuses on the process period from the initial stage of a firm to the development stage. To comprehend the effects of the pre-entry and post-entry efforts on the growth pattern of new firms in a dynamic way, the experiences/efforts and the growth of firms are analyzed quantitatively by the use of firms' financial panel data.

Objective of this study

The R&Cs should be considered for the firm's unobserved heterogeneity. The present research aims to prove that pre-entry experience and post-entry efforts contribute to the development the R&Cs that affect the future growth of firms; by viewing the result of this investigation through the lens of nature and nurture, it is hoped that new implications for the growth of firms can be derived to better inform management and policy-makers. This research shows the limitation of the previous firm growth model, which focused on the size and age of firms in predicting growth. The creation and evolution of R&Cs are explained by using the combined theories of organization ecology and evolutionary economics along with a resource-based perspective; this allows the previously ignored role of post-entry efforts to be considered as an explanatory factor. That is, by adding the effect of post-entry effort to the effect of pre-entry experience (that organization ecology has previously focused on), the theories and results that the existing researches have presented can be interpreted from novel perspectives. In addition, new firms' activities can either be negative or beneficial to the future growth of the firms, and the present research is intended to demonstrate this with proofs and analyses.

Structure and methods of the thesis

Chapter Two presents the existing theoretical background of firm growth. In addition, the history and problems of the relationship between theories and models firm growth is explained. To understand the limitations of the growth model, various firm growth theories and models will be reviewed, and criticism of the previous growth theories is presented and discussed.

Chapter Three presents the alternative theoretical framework proposed in the present thesis to analyze the so-called ‘nature/nurture’ characteristics of the R&Cs under an integrated perspective of organization ecology and evolutionary economics. Simultaneously, the core role of the recent resource-based view in combining these two theories is explained. To assist in understanding the nature/nurture perspective, the relationship between pre- and post-entry efforts and capabilities will be explained with a review of existing literature and previous research results. In addition, among the many factors that determine firms’ growth, empirical results concerning some representative factors, such as profit, productivity, innovation, age, size, competition, will be confirmed and compared. It should be understood that these factors are another set of results by the particular R&Cs that the firms have and the characteristics of the R&Cs and their dynamic changes are the major variants of the firms’ growth.

Chapter Four presents the analytical findings on how the *de alio* and *de novo* statuses, which have been studied extensively in terms of the effect of pre-entry experience on the growth or survival of firms, have influenced the growth of firms and how long the effects of the pre-entry experiences last. The emergent new and renewable energy sector has with a short history of post-entry efforts; thus, it is a proper industry for understanding the effects of inherited R&Cs gained from pre-entry experience.

Chapter Five presents findings from a direct comparison of the effects of the inherited and nurtured R&Cs. For inherited R&Cs, depending on the existence of pre-entry experience, the concepts of *de alio* and *de novo* are used. For nurtured R&Cs, among the R&Cs that Helfat and Lieberman (2002) categorized. In this study, a representative selection including tangible assets, R&D intensity, and employees is used for measurement of the extent of firms' post-entry effort. The R&Cs can be categorized into core vs. complementary and specialized vs. generalized (Helfat and Lieberman, 2002). Tangible assets are complementary and generalized R&Cs. R&D intensity is core and specialized, and employees would be in the middle of each spectra.

Finally, Chapter Six explains the conclusions drawn from the research review and the empirical results, and implications are drawn for strategic managements and policies making. The nature vs. nurture dichotomy contributed to the understanding of the fundamentals of human beings; it is concluded that this research could initiate an analogous nature vs. nurture dispute to identify factors involved in firm growth and contribute to a better understanding of firm growth per se.

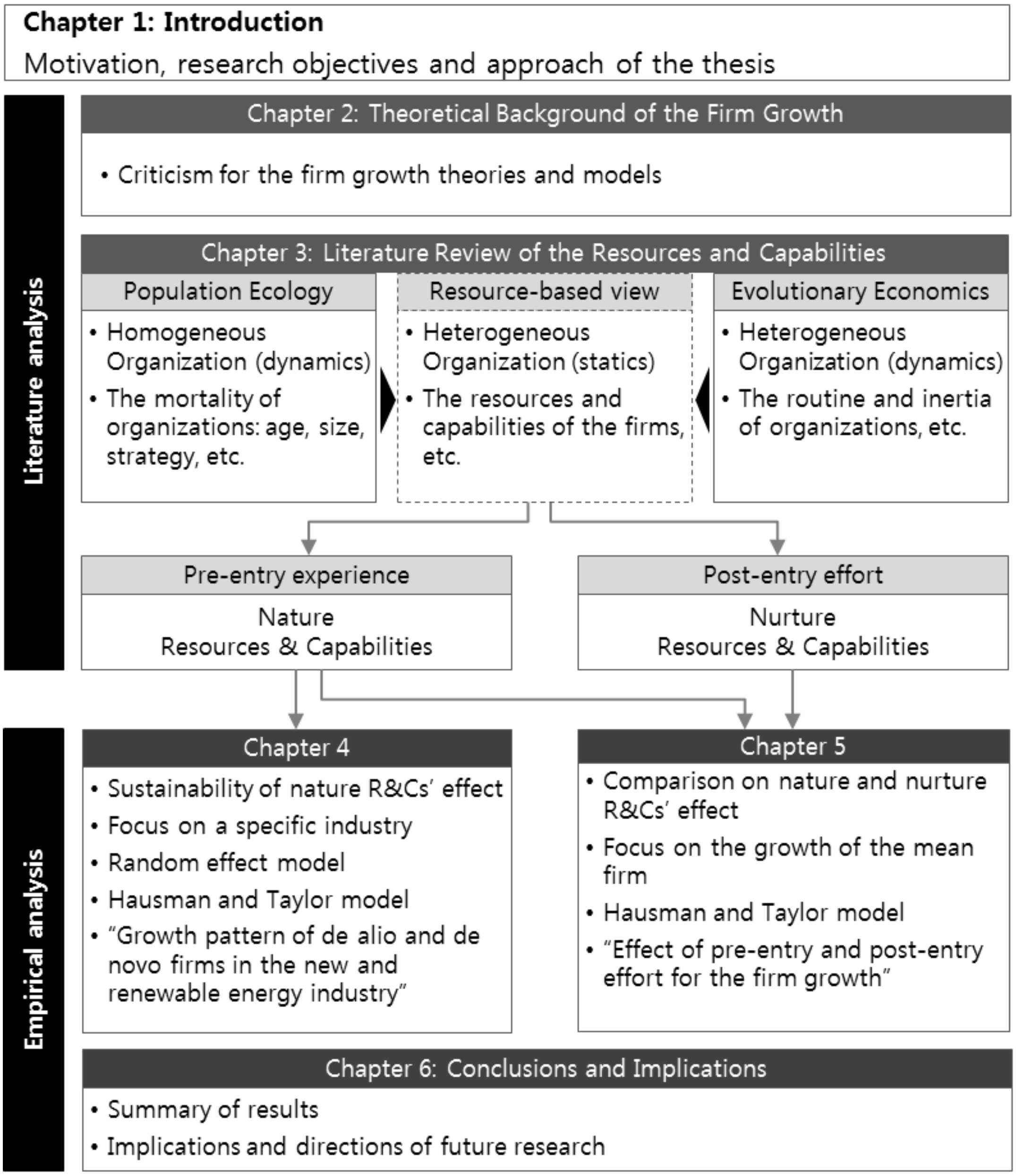

Figure 2. Structure and methods of the thesis

Chapter 2. Theoretical Background of the Firm Growth

2.1 Introduction

The growth theory of firms started with Penrose's (1959) *Theory of the Growth of the Firm* and became a popular research area in economics and business administration. There are many growth theories and related empirical analyses that seek to explain the fundamentals of the growth of economies and firms, including neo-classical growth, endogenous growth, evolutionary economics, and other various growth theories. It is clear that firm growth is directly related to firms' survival, which has an indirect influence on the national economic development. Thus, managers and the policy-makers continue to pay attention to firm growth theory and empirical data. As the types of industries and firms diversify over time and there are frequent births/exits of firms, the growth paths of individual firms are complicated. Multiple empirical analyses have demonstrated patterns in firm growth. However, it is not easy to adequately explain (in one or two factors) growth in firms that have diverse growth paths.

The reason why firm growth continues to receive the attention is that there is discordance between theory and empirical data. The latest growth theory focuses on the firm's internal activities, while the traditional growth model uses firm's external features such as firm's size and age, that are easy to collect as data and have been frequently used as proxy variables in traditional economic growth models. Therefore, there are fundamental differences between traditional and newer growth models.

For example, growth models are designed based on the theories explaining the economic growth. The neo-classical growth theory uses the production function, composed of capital and labor, and the endogenous growth theory adopts knowledge such as technological progress as part of the production function. Since economic growth can be considered as the aggregation of the firm growth and the growth of the economy, firm growth has similar fundamentals to those of economic growth, the similar models can explain both. However, if models are designed by considering firm growth simply in terms of size or age, it is limited in its ability to explain the effects of each firm’s idiosyncratic R&Cs, learning abilities, experience and efforts, and routines, all of which determine the pace of firm growth. The firm’s unobserved heterogeneity is difficult to explain by the firm’s size and age. That is, the firm’s growth is influenced by its internal factors, such as firms’ internal activities and organizational types as well, as firms’ external factors, such as the industry structure and other competitive firms’ activities. Therefore, the macro indicators such as size and age are limited in their ability to estimate firm growth dynamically. If the firm growth theory focuses on the firm’s actual activities, these should be reflected in the results of the empirical analysis. To do so, it is necessary to develop a model fit the empirical analysis or to develop appropriate proxy variables.

A typical example of the development of the growth model is the endogenous growth theory. In the middle of the 20^{th} century, when the importance of technological change was emphasized, the technological innovation factor entered the economics, developing into the endogenous growth theory. The endogenous growth theory defined technological innovation as “knowledge stock.” Unfortunately, in explaining the accumulation of knowledge, the endogenous growth theory still depends on the R&D investment amount or time variables, which are essentially size and age variables. It is still meaningful that endogenous growth theory applied the accumulation of knowledge to the growth model. However, it is necessary to develop the endogenous growth theory to allow it to use the firm growth model in explaining the firm’s characteristics shown in the knowledge accumulation process, such as the effects of R&Cs influenced by the firm’s internal absorptive capacity, experiences, and other various efforts.

Sizable firms with a diverse range of products are frequently defeated by small firms that have flexible and innovative organizations, often very rapidly. Moreover, firms with the same amount of asset, employee number or age turn out to have different results and sales growth rates. However, the traditional firm growth model focuses rather on the firm’s size variable and age variables, such as assets and employment (that used to be central values in the economic growth theory) rather than firms’ unique features, internal capabilities, efforts, or processes. Thus, it is limited in its ability to explain differences in growth rates. Thus, more theoretical and empirical focuses have been placed on the competitive advantage that individual firms have and how core capabilities make effect on firm growth. In the modern business environment, where technology dependency and competition, and the resulting environmental change, are high, it is not proper to explain the firm’s growth based only on the firm’s external factors such as size or age.

Valid criteria to determine a firm’s future growth should include how innovative the firm can be, how responsive the firm can be to environmental change, and how differentiated and competitive the firm’s internal capabilities, such as experiences or efforts, are against other firms. For researchers, these factors are difficult to define and quantify; however, for the development of the growth theory and model, it is essential to develop similar proxy variables and make the empirical analysis dynamic.

The focus of the current research is not to create a new firm growth theory; rather, it is to assess whether the models used in the previous growth theory or empirical analysis make an actual impact on the firm’s performance and to search for more realistic growth principles that reflect individual firm’s characteristics. Specifically, it is assumed that the R&Cs inherited from the firm’s pre-entry experiences as well as those newly accumulated by means of the efforts immediately after the firm’s establishment have a huge impact on the firm’s growth; thus, the present research intends to apply these explanatory variables, which are not considered in the existing growth model.

Firm growth is not explained by simple and static variables such as tangible assets, including the investment in facilities as a proxy for the firm’s size variable, R&D investment as a proxy for the innovative activity, and the number of employees as a proxy for human capital. It would be desirable to measure how much more effort was made immediately after the firm’s establishment relative to competitors and interpret the firm’s growth theory with these experiences or efforts as variables.

2.2 Firm's growth: Theory and practice

Penrose (1959) proposed the firm's growth theory that was different from the neo-classical economy theory, explaining the firm's growth model using the price and the quantity its products. Penrose argued that the actual firms should be viewed as manageable organizations and the human resources inside the firms can induce or restrict the firms' growth rates. For Penrose, the firm's growth implied that "history matters." That is, for firms, the market opportunities and the services from the firm's resources interact with each other and are accumulated inside the firm. Penrose argued that the growth is the basis of evolution, and the evolution process includes the accumulation of knowledge, which is unique to the firm (Penrose, 1995).

Penrose's perspective on firm growth differed from those of existing industrial economists, which based on the aggregate data. Penrose focuses rather on the internal dynamics and the firm's learning process as the unit of analysis. However, there is a difference between a theory and an actual learning model. The econometric model is a simple model based on the substantial assumption and has restrictions in explaining the firm's actual growth and survival. For example, Jovanovic's learning model does not reflect technological progress and assumes that the changes of all demands are predictable (Jovanovic, 1982). It is true that there is still such a gap in reality if accepting Penrose's position.

Penrose's argument later became the basis for the resource-based view. Since then, various management theories have been introduced that consider the origin of the firm's growth to include the firm's idiosyncratic efforts, the firm's accumulated R&Cs, and the firm-specific competence combined with these two factors. However, in actual empirical analyses, it seems that even Penrose herself did not reflect the theory adequately in the model. It was asserted that the firm-specific resources, capabilities, experiences, efforts, and technologies were not sufficiently used as variables or causes in considering firm growth (Garnsey, 1998).

In the resources-based view, firms locate their positions in their surrounding environment through the interactions between R&Cs and customers, distributors, suppliers, and competitors. In these interactions, firms build tangible assets such as equipment or buildings as well as intangible assets, such as specialization or reputation, and continue to grow. Therefore, the collectable data, such as assets or employee members, become the standard for measuring growth, and the uncollectable data, such as problem-solving capabilities, learning abilities, experiences, or knowhow, which significant impacts on the actual growth of firms, cannot be utilized in the empirical analysis.

In the course of explaining the interest in the firm's entry and exit and its evolutionary process, the interest in individual firms was naturally changed to the interest in the aggregate data, such as population and the fitness distribution between firms and populations. Even organization ecology, the representative evolutionary theory, becomes unduly focused on the firm's survival and exit rather than the firm's growth through the aggregate data (Hannan and Carroll, 1992).

Another evolutionary theory, evolutionary economics, explains the firm's growth differently from Penrose's theory. It considers firms' rather than individuals' actions as key factors. The individuals' actions are seen to be determined by their firms. Thus, the focus is on the firm rather than on the individuals. As a result, the growth of small-sized firms (such as new firms) that have impacts from the individual-level, including the entrepreneur's characteristics, does not seem to be considered adequately in evolutionary economics. In particular, new firm's financial performance fluctuates in the beginning of the business; thus, research examining the firm's evolutionary process in the macro-perspective, such as evolutionary economics, does not attend to the short-term phenomenon in terms of the firm's financial size, and this might lead to misrepresentation of the firm's performance. Therefore, research based on organization ecology considers the new firm's average survival period or employees' growth rate. The problem is that the number of the employees for new firms does not fluctuate significantly.

The firm's growth path passes the initial phase, the mature phase, and the decline phase. In the beginning, firms typically make efforts to acquire R&Cs prior to the growth preparation. As in the discussion of *de alio* and *de novo* market entrants, experiences prior to establishment make a difference in the R&Cs from the beginning (Helfat and Lieberman, 2002). Findings have shown that only 40% of the new firms survive for 6 years, and many firms are expelled in the beginning. It has been reported that 38% of the surviving firms do not show fluctuation in terms of the number of employees (Kirchhoff,

1994) and thus, in the beginning of the firm, because of the issues such as self-selection, it is not easy to show the statistical relationship between the firm’s roles and the firm’s growth with the data used in the theoretical perspectives of organization ecology and evolutionary economics. The firms entering the market make efforts to acquire R&Cs. In the course of mobilization and deployment, R&Cs are made ready to be extended and developed. When firms grow to a certain level, they can escape the risk of failing. The R&Cs become successful when they have mutual commitment with the market; however, this can cause problems when there are new products or services or changes in the market (Garnsey, 1998).

Firms develop R&Cs and acquire competitiveness through sufficient experiences and efforts. Firms’ learning processes include problem-solving routines, and firms extend their alliances with customers and distributors. The sales increase, and products and services are extended. The evolutionary economists emphasize that routines should be included among essential capabilities for the effective adaptation of firms to the industrial environment. This process starts at the very beginning of the firm’s initial period (Nelson, 1995).

For large firms, growth is explained using the conventional economic theory. It is reported that the firms need to grow until they reach the optimal size considering the efficiency in the industry, and the level of input capital is determined through the production function. In this context, the innovative technology and the organizational capabilities play the role of adjusting the level of input. Since the perspective of the economic theory looks into the firm’s growth as a function of the size and the age in the equilibrium state, it has the limitation of not being able to interpret properly the effects of R&Cs that are unique to individual firms.

One of the phenomena discovered in terms of the firm’s growth is growth reversal. The unexpected shortage of resources or capabilities, wrong decision-making, competitor’s success, or the appearance of new products might cause growing firms to become stagnant or fall behind the competitors, and their growth stops or reverses. In the perspective of the organizational ecology, the niche strategy becomes useless due to abrupt environmental change, and the possibility of growth reversal increases. However, the problem-solving routine helps the recovery of the growth rate. The firms that have effective routines to solve problems with technological innovation will be able to solve technical problems, and the firms with the routines to acquire complementary assets through alliance will solve problems through alliance. When problems are solved, firms will gain reputation, orders for the products will increase, and so will the sales.

Growth reversal is a phenomenon that commonly occurs; however, is not seriously considered in growth theory. As for the growth reversal phenomenon, external effects such as industrial environment, appearance of competitors, and macro-economic shock have an influence; however, growth reversal becomes entrenched when there are no proper human resources or leadership to solve problems in the firms. To preempt the growth reversal phenomenon, it is necessary to have the capability to prepare for the future and to promptly overcome the risks, and these are embodied in decision-makers’ capabilities inside the firms and are also the result of experiences and knowledge accumulated in the firms (Garnsey, 1998).

In empirical analysis on the firm's growth, it is not easy to consider the course of growth reversal. It is difficult to recognize growth reversal in the research on the firm's survival rate, because it is not easy to segment the change process during the growing process. However, if the firm's performance is divided into short-term and long-term and the growing pattern is analyzed dynamically, the growth reversal phenomenon can be discovered and its causes can be traced.

2.3 History and problems of firm growth models

2.3.1 The relationship between firm growth theory and models

The original firm growth model focused on the firm's size. Because it was thought that firms grow until they reach the optimal size, the firm's growth was discussed through the optimal size theory. This used a statistical framework and static analysis using size distribution and searched for the optimal size in the equilibrium state; therefore had limitations in interpreting the firm's short-term and long-term growth changes dynamically.

As the industrial environment becomes increasingly diverse and the uncertainty of the market increases, the issues of technological innovation and competition play an increasingly significant role in firm growth. This highlights the limitation of the neoclassical growth theory, which was the basis of the existing growth theory, and the endogenous growth theory was generated to overcome this limitation. The endogenous growth theory includes knowledge variables such as R&D or innovation as factors in the production along with the capital and the labor variables, and knowledge is considered as endogenous variables (as opposed to an exogenous variable). That is, knowledge contributes to total production, and the speed of knowledge accumulation is influenced by the size or the growth rate of the total production and the capital. Specifically, the speed of the knowledge accumulation is influenced by R&D investment, and as the experience and the size of the production increase, the learning effects increase the amount of knowledge. That is, as the total factor productivity (TFP) considering the effects of the technological innovation is included in the production function, the limitation of neo-classical growth theory is overcome.

Research into the path-dependency of the evolutionary economics has been conducted as another topic of the firm's growth. It maintains that firms have unique capabilities, and the organizations' routines play an important role in connecting the success of the past to the success of the future. It also explains the firm's growth with the theory that the firm-specific R&Cs are accumulated and become competitive advantage capabilities, and the firms thereby continue the long-term growth. Sometimes, poor routines result in structural inertia, which causes the opposite effects, restricting the firm's prompt adaptation to the environmental change, halting or reversing growth, and even resulting in firm failure. The firm's growth theory in terms of the evolutionary economy is different from the existing growth theories in that it focuses on the firm-specific routine as the cause to the growth as well as interpreting the growth theory not with labor and capital production functions but with the ability to adapt to environmental change and the firm's internal R&Cs.

In order to prove the rationality of the evolutionary growth theory through empirical analysis, it is essential to secure appropriate data and models that consider the firm's heterogeneity. In addition, the quantitative variables used to judge the firm's internal capabilities, including the routines, should be applied to the growth model. In addition, the relationship between these variables and the firm's growth should be explained meaningfully.

The development of firm growth theory is accompanied by the development of empirical analysis methods. Early (macroeconomic) empirical analysis could only see the average effect of the average firms. Therefore, it may have been easy to assess the firm's growth through the distribution of the size and the age, which are easily aggregated. However, the innovating firm's growth is essentially due to heterogeneous factors. Thus, it is necessary to reflect the firms' idiosyncratic talents, efforts, and routine in an accurate firm growth theory.

2.3.2 The measurement indicators for firm growth

The measurement indicators frequently used in firm growth research are the growth rates of sales, employment, and tangible asset. Currently, there are more industries in which firm growth is influenced by the intangible assets; thus, it would be logically problematic if the tangible assets alone represent a firm's growth rate.

As for employment, it does not require artificial deflation and is subject to fewer statistical errors or adjustments. Thus, it is used often considered along with the growth rate of sales. The growth rate of sales makes the best representation of the short/long-term changes, and is used most frequently as the growth indicator (Coad, 2009).

To measure the firm's growth, proportional growth is mainly used. Log-difference of size type is most popular, and its advantage is that the estimated result is not influenced by the heteroskedasticity. Its value comes out smaller than the % type, as demonstrated in Eq. (1):

$$g_{i,t} = \frac{S_{i,t} - S_{i,t-1}}{S_{t-1}} = \frac{S_{i,t}}{S_{i,t-1}} - 1, \quad \log(g_{i,t}) = \log(S_{i,t}) - \log(S_{i,t-1}) . \qquad \text{Eq. (1)}$$

Any indicators can be used to measure the firm's growth, and it is desirable for a researcher to select the right indicators by considering the industry for analysis and the research topic. Thus, growth theory has more interest in the variables explaining reasons for the growth rather than the growth measurement indicators.

2.3.3 **Development of growth models**

From neo-classical to endogenous growth

The neo-classical growth theory, which used to be the main growth theory, has various limitations. To overcome these, the endogenous growth theory was proposed.

The neo-classical growth theory argues that the causes of growth are exogenous technological progress and increases of labor power (Solow, 1956). When capital is accumulated, the marginal productivity is diminished. Romer's (1986) and Lucas Jr.'s (1988) first developed the endogenous growth theory in which the economic growth is considered using endogenous factors. The endogenous growth theory argues that technological advance is possible endogenously and human capital is recognized as the core variable for the endogenous growth; thus, more efforts are required to expand the human capital. This growth theory takes the theoretical approach of the macro economy and does not consider the individual firms' unique characteristics. Therefore, it also has a limitation to explain a specific firm's growth pattern.

Traditionally, the growth theory uses the production function model. The equation to analyze the firm's growth involves the estimation of the logarithmic transformation model using the conventional Cobb-Douglas production function. This is a conventional production function composed of the two production factors of capital and labor. The efficiency parameter conforming to A in Eq. (2) can have many interpretations; however, it is mainly understood as TFP. Excepting A, total production is composed of capital and labor functions. That is, the firm's growth is composed of the capital and the labor functions, which have high correlation with the size of the firm.

$$Y_{i,t} = AF(C_{i,t}, L_{i,t}) = AC_{i,t}^{\alpha} L_{i,t}^{\beta}. \qquad \text{Eq. (2)}$$

where Y is total production, C is capital stock, L is total labor, A is efficiency parameter, inferior letter i=1,2,… N is a firm, t=1,2,…., and T is time.

The firm's management performance can be measured by its financial statement. The factors that determine the firm's performance are productivity, profitability, efficiency, growth, and so on, and the indicators representing these factors are frequently used. Productivity is used as an indicator for management performance to represent the firm's external growth size (e.g., production per employee). Profitability is used as an indicator for management performance to represent the result of the firm's activity (e.g., ratio of operating profit to net sales, ratio of net income to net sales, etc.). Efficiency is used as an indicator to show how productive a firm's production method is (ratio of labor cost to the value added), and the estimation of TFP is accompanied. These factors can be the input indicators as well as the output indicators of the firm's performance excluding growth. Growth is an indicator to show how much the firm's management size, such as assets, capital, and so on, and activity performance increase year on year, and it is used as an indirect indicator to show the firm's competitiveness or profit-making capability in the future (e.g., sales growth rate, total asset growth rate, etc.). It is used as a representative output indicator.

TFP is an indicator to show the change of the production by the total input of the factors, unlike labor productivity or capital productivity, to represent the individual factors' productivity. As mentioned above, A in the Cobb-Douglas function means TFP. To estimate the TFP, an empirical model that has a natural log on both sides of the production function can be used, as in Eq. (3):

$$\ln Y_{i,t} = c + \alpha \ln C_{i,t} + \beta \ln L_{i,t} + \varepsilon_{i,t} \qquad \text{Eq. (3)}$$

where Y is total production, C is capital stock, L is total labor, c is constant term, inferior letter i=1,2,… N is a firm, t=1,2,…., and T is time.

The equation above categorizes the firm's growth into capital contribution, labor contribution, and Solow residual.[1] Solow residual refers to the influence on the firm's growth, which cannot be explained by the quantitative increase of capital accumulation or labor input. It can represent the individual firm's technological development or innovation. The indicator's value of the Solow residual is detected as TFP, representing technological progress.

As for the indicators of productivity, growth, and efficiency that can be used as dependent variables of the firm's management performance equation, it is expected intuitively that they might be heavily influenced by the firm's size and performance. In

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[1] $\hat{c} + \hat{\varepsilon}_{i,t} = \ln A$

particular, the increase of the input of capital and labor is connected to the increase of the firm's size. Accordingly, the changes in productivity, growth, and efficiency can be observed; therefore, it is convenient to interpret the firm's growth as production function in the macro perspective, and for this reason it is still popularly used.

Gibrat's law

The most well-known law in the empirical analysis of the firm's growth is Gibrat's law.

If the firm's size is defined as x_t at time t and the random variable is ε_t to the individual firm from t-1 to t, then

$$x_t - x_{t-1} = \varepsilon_t x_{t-1} \qquad \text{Eq. (4)}$$

$$x_t = (1+\varepsilon_t)x_{t-1} = x_0(1+\varepsilon_1)(1+\varepsilon_2)...(1+\varepsilon_t)\text{, and} \qquad \text{Eq. (5)}$$

$$\log(x_t) \approx \log(x_o) + \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_t = \log(x_0) + \sum_{s=1}^{t} \varepsilon_s \,. \qquad \text{Eq. (6)}$$

When t is big, the $\log(x_0)$ term is insignificant.

$$\log(x_t) \approx \sum_{s=1}^{t} \varepsilon_s \,. \qquad \text{Eq. (7)}$$

That is, at time t, the firm's size is influenced only by the idiosyncratic history of multiplicative shocks.

In terms of the firm's growth, Gibrat's law uses the following form:

$$\log(x_t) = \alpha + \beta \log(x_{t-1}) + \varepsilon . \qquad \text{Eq. (8)}$$

Where x_t is the firm's size, α is the constant term (industry-wide growth trend), and ε is the residual error. If the firm's growth is irrelevant to its size, β has a unity value. When β is less than 1, it means that smaller firms grow faster than big firms; on the contrary, if it is bigger than 1, it means that bigger firms grow relatively faster. Much empirical research has reported that β is a little less than 1, which means that small firms tend to grow more rapidly than large firms.

Growth models after Gibrat's law and application examples

As an alternative to Gibrat's model in the firm's growth, Steindl (1965) suggested Pareto instead of lognormal distribution; however, this still emphasizes the stochastic models of growth. In particular, it excludes the analysis on small firms, and it is not useful in the analysis of the relations between the employment growth and the size of the company (Steindl, 1965).

Sutton (1997) developed a new stochastic firm growth model. He explained the firm's growth in the context of economic theories such as market behavior, game theory, and so on based on the manufacturing industry's industry level (Sutton, 1997). His model used two conditions. First, the probability of the next market opportunity generated by the currently active firm is the non-decreasing function of the firm's size. Second, the probability of this opportunity's continuity by the new entrant is constant according to time. It is a more general model than Gibrat's, since new firms are included in the model.

Geroski (1998) suggested six stylized facts of the firm's growth given his research results. The research was conducted on a sample of 280 big firms in the UK; thus, it hardly represents firms as a whole. However, the result shows that big firms grow more slowly than small firms. This research proves that, in terms of firm growth, there are no consistent results and trends (Geroski, 1998).

Evans (1987a) researched firm growth with 20,000 manufacturing firms in the U.S., and when measuring the firm's growth with employment, smaller firms grow faster than big firms, and it shows results consistent with those of Geroski's (1998) UK firms . However, the negative relationship between the size and the growth is strongly non-linear, and Gibrat's law of proportionate effect is not supported. Evans proves in the research on the firm's age and growth that younger and smaller firms grow faster and that there is a positive effect between age and size logarithms. Evans' research shows that age has a negative effect on growth, unlike in the learning by doing model.[2]

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[2] Evans' model can statistically verify Gibrat's law and Jovanovic's laws.

$$firm\_growth = \ln(S_{t'} / S_t) / (t' - t) = \ln G(A_t, S_t) + u_t ,$$

where S is the size of the firm measured by the number of the employees or the sales, t' is the last year of the sample, t is the first year of the sample, A is the firm's age from the establishment year to the first year of the sample, and u is an error term. The elasticity of the end-term firm's size to the initial firm's size and the elasticity of the end-term firm's size to the initial firm's age are defined as follows, where the partial differential of the growth function for the size and the age are defined as g_s, and g_a

Hall's (1987) research also measures firm growth with employment. It shows that smaller firms grow faster than big firms, and the research does not consider the firm's age, instead using capital expenditure and R&D investment logarithms for the variables. His research proved that these variables have a positive effect on firm growth.

It is known that the effect of age diminishes as time goes by. It is explained by the principle that because the technological progress is faster than the past, the importance of past experience decreases (Hart, 2000). These days, regardless of the age, the firms should adopt new technologies; thus, the accumulation from the previous output and experiences becomes obsolete more quickly.

2.3.4 **Criticism against the previous growth model**

As mentioned above, according to the neoclassical growth model, firms grow until the firm's size reaches the minimum average cost. There is no incentive for the growth beyond that point. This means that when the size reaches the equilibrium state it ceases to grow. This fails to explain the actual situation, where firms continue to expand through mergers and diversification. However, it can explain the small firms' fast growth compared to big firms' (up to the efficient size). Nevertheless, since small firms are subject to influence by various government's policies and are exposed to an imperfect

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$$E_s = \frac{\partial \ln(S_{t'})}{\partial \ln(S_t)} = 1 + dg_s, \quad E_a = \frac{\partial \ln(S_{t'})}{\partial \ln(A_t)} = 1 + dg_a, \quad (d = t' - t)$$'

and when d is normalized as 1, if it conforms to Gibrat' s law, g_s=0 and, E_s=1. If it conforms to Jovanovic's law, it is g_a<0.

competition environment, which can affect the growth speed, the neo-classical theory alone cannot explain the true situation.

The firm's growth is determined not only by cost but by price, credit condition, product's diversity, quality, service, and demand of a specific product. Thus, the firm's growth in the diversely imperfect competitive situation is not captured by the neo-classical theory.

Though the endogenous growth theory adopted the knowledge capital as a drive for the growth to the model and thereby overcame many limitations of the growth theory, it does not reflect the actual activities of the individual firms on the measurement of TFP.

The following example is the interpretation of the growth rate[3] of TFP. In the assumed production function, TFP is defined as the rest excluding the contribution of two input factors (labor and capital) to the production, and the elasticity method is shown as follows for the total factor productivity growth rate (TFPG), which is defined by Eq. (9):

$$TFPG_i \equiv \frac{\dot{Y}_i}{Y_i} - \hat{\alpha}_i \frac{\dot{L}_i}{L_i} - (1 - \hat{\alpha}_i)\frac{\dot{C}_i}{C_i} = \lambda_i + \gamma_i \frac{\dot{K}_i}{K_i} + u_i . \qquad \text{Eq. (9)}$$

Where the total of the factor compensation share for the input factor is assumed to be 1, Y = yield, L = labor, C = capital, K = knowledge stock, t = time, and u = error term. The variable with a period (.) means the increased share for the time and thus, each

[3] Suh (2005)'s writing form was used.

variable term is marked as growth rate.

Since the parameter γ_i conforms to yield elasticity (= $\frac{\partial Y}{\partial K}\frac{K}{Y} = \rho \cdot \frac{K}{Y}$),

$$TFPG_i = \lambda_i + \rho_i \frac{\dot{K}_i}{Y_i} + u_i \,. \qquad \text{Eq. (10)}$$

Thus, Eq. (9) can be converted to Eq. (10), and ρ is the conventional return rate of the knowledge stock. Ultimately, for both yield elasticity and return rate, the calculation of knowledge stock is an important factor. The accumulation of the knowledge stock is determined by depreciation rates (obsolescence rates), R&D investment, and other factors and the calculation result of the knowledge stock is influenced by the depreciation rates (obsolescence rates) (Hall and Mairesse, 1995). In particular, in the estimation of elasticity, the knowledge stock (K/Y) against the yield is influenced by R&D intensity, which is the calculation of R&D investment against the sales by using the actually observable R&D investment.

After all, the TFP contributing to the rest of the production excluding the two direct input factors is influenced by the R&D intensity, which is also influenced by the firm's size (i.e. the sales). Thus, it is clear that R&D intensity is the factor influencing the firm's performance, like the labor and capital that have direct influences on the firm's size; however, it does not represent the individual firm's unique activities.

TFP increase can be achieved through the technology innovation, as described above.

Since TFP is the production efficiency that reflects not only labor productivity but worker's work capability, capital investment amount, technology level, and so on, it reflects technology, labor and management, management system, law, and system, which are not included in the measurement of single factor – such as labor, capital and so on – productivity. However, even in the case of TFP representing the individual firm's technological development or innovation, because the focus is not on the individual firm's activity but on the firm's size or age, it is predicted that TFP increases as the size increases.

In addition, it has weak points given that the meaning of technological innovation is not specific and collecting quantitative data from individual firms is not easy. The empirical analyses on the effects other than the size and the age in the firm's performance have been conducted restrictively so far due to the data issue and the limitation of the analysis model.

Klette's model[4] shows that the performance indicator of the TFP explains the characteristics of the R&D investment (Klette, 1996).

Klette's (1996) model can be used for prediction according to the characteristics of the R&D investment and substitutes the knowledge stock (Klette & Johansen, 1998). The performance indicator in Klette's model conforms to the TFP in the production function and is defined by Eq. (11):

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4 Suh (2005)'s writing form was used.

$$\hat{a}_{it} = (\rho - \nu)\hat{a}_{it-1} + \gamma\nu\hat{r}_{it-1} + \lambda_1\hat{i}_{it-1} + \lambda_2\hat{x}^C_{it-1} + \hat{e}_{it}\ . \qquad \text{Eq. (11)}$$

where all the variables are defined as the ratio between reference firm and individual firm, $\hat{a}_{it}$ is the individual firm's performance indicator, $\hat{r}_{it-1}$ is the R&D investment for the entire period, $\hat{i}_{it-1}$ is the facility investment rate against the capital stock for the entire period, $\hat{x}^C_{it-1}$ is the capital stock for the entire period, and ν is the innovative parameter for the firm's growth (the effect to increase the sales through the product innovation and process innovation by the knowledge stock [marginal product of knowledge with respect to sales]) (Klette, 1996; Klette and Johansen, 1998).

Klette's (1996) model also has limitation. As for the representation of the causal relation between productivity and R&D investment, it has a spurious correlation (Suh, 2005). That is, R&D can enhance the productivity; however, since the firms with higher productivity make more profits and are able to have more R&D investment, this spurious correlation occurs. There is no way to solve this problem perfectly (Stoneman, 1995). Efforts can be made with a method of setting some time-lag for the R&D investment or a method of assuming multiple causal relations by setting simultaneous equations with acquiring over variables. R&D intensity is generally considered to be independent of the firm's size, and is thus used instead of R&D investment (Suh, 2005). However, to see the firm's growth considering individual firm's characteristics, it is still necessary to develop a variable to show the unobserved heterogeneity of the firms other than R&D intensity.

For example, it should be a variable that is independent of the firm’s size or age but still reflects the firm’s characteristics and clarifies multi-causal relations.

Firms increase the assets, invest in R&D, and supplement employees in order to generate performances and contribute to growth. So far, the return rate of R&D investment has had a big effect on productivity; thus, the R&D effects were significantly considered in the performance indicator of the production function, and it became a stylized fact that R&D investment observes Gibrat’s law, which follows the random walk (Klette and Griliches, 2000).

The point to be careful about R&D investment for the firm’s growth is to separate the productivity effect of R&D investment and the productivity of R&D investment itself. That is, firms with more R&D investment have higher productivity, though the correlation between R&D investment and the increase of productivity is not high (Suh, 2005). In particular, the activities for the firm’s performance should contribute not only to the short-term performance but also to the long-term performance (i.e., continuously).

It is true that the process to verify the effects of technological innovation by introducing TFP to the production function facilitated the studies on the roles of R&D activities in the production process or in the economic growth process. However, there is a limitation of the model in that the theoretical prediction of the model used in the empirical analysis does not conform to the firm’s performance. There has been extensive research on the effect of firm’s activities on firm growth; however, difficulty in collecting appropriate data has been an obstacle to detailed research. It is necessary to secure data representing the unobserved heterogeneity of firms and, more importantly, to compose the theoretical prediction of the model more realistically where firms' idiosyncratic variables are used in the empirical analysis. Therefore, securing the right data is important, though the more important task is to conduct a strictly empirical analysis with a realistic theoretical model.

2.3.5 Evolutionary growth theory

Nelson and Winter (1982) proposed evolutionary theory in the discussion of the firm growth. They explained that firms use routines reflecting the idiosyncratic firm instead of the optimization in the market and tend to adapt themselves automatically to the change of the market. They maintained that the know-how that firm's members build from their experiences and skills are passed on to the firm's new members, and, thus, the past's routine makes an impact on the future. When there are environmental changes, successful firms change their routines to fit the new environment.

Measuring success is possible by measuring the labor productivity and so on, and firms with high productivity are known to maintain that level of productivity for 2–4 years (Oulton, 1998). It is true that some types of firms with good routines infrequently fail. However, the general perspective of evolutionary economics (maintaining that success leads to further success and failure leads to further failure) clearly contradicts the pure stochastic models of growth that argue that the growth rate of the surviving firms is determined randomly regardless of the previous success, as with Gibrat's law of proportionate effect (Hart, 2000).

The dynamic models of entry and exit for the evolutionary growth model were developed by Brock (1972) and Smith (1974). In this model type, it is assumed that the firms have the same size. The equilibrium model does not include firm-specific stochastic elements that cause firm's dynamics, and this issue was first discussed by Jovanovic (1982). Pakes and Ericson (1989) developed the implication of the learning model and suggested the idea that a firm's production is influenced by uncertain performance as well as investment.

The two models of Jovanovic (1982) and Pakes and Ericson (1989) provide many implications for the firm-level dynamics (Hopenhayn, 1992). The learning model explains the firm's evolution with the firm's size distribution according to age. The majority of related research has been on the firm's growth judged by the survival rate.

The firm's size measured by input or output is explained by the increase function related to productivity. Hopenhayn (1992) explains theoretically that the older, bigger, and more profitable the firms are, the higher the survival rates are. Hopenhayn (1992) explains the entry and exit in terms of entrants' change of distribution. Learning models can be divided into passive learning and active learning, described in the following two subsections.

Passive learning growth theory

The passive learning model uses a Bayesian model to explain that efficient firms grow and survive and inefficient firms decline. In particular, Jovanovic's (1982) passive learning deals with small industries with homogeneous products, where the time path of the demand for the product is determined and known. In addition, the factors are given at the same price. In this competitive environment, firms are assigned uncertain and time-invariant characteristics in the beginning. Each firm should make a decision on the strategy in each period. That is, firms should decide whether they exit, maintain size, increase size, or reduce size. Since this model specifically follows the selection process, the most efficient firms survive and grow, and less efficient firms are stuck in the market or leave the market. Since it assumes small industry size and product homogeneity, it cannot seek niche strategies with the characteristics of different paths from lognormal distribution. If new firms in the suboptimal scale find the true cost to be low, they expedite the growth and adjust their size as fast as they can. In this model, as time goes by, the size distribution of the survival firms is stochastically interesting.

Active learning growth theory

Ericson and Pakes' (1995) active learning assumes that all decisions that firms make are intended to maximize the discounted value of the predicted future net cash flow under the condition of the current information set, as in the passive learning model (Ericson and Pakes, 1995). However, the active learning model assumes that firms know all about their characteristics and those of competitors under the current structural condition according to the future distribution of the industry structure. The Jovanovic model's assumptions of small industry size and product homogeneity are alleviated in Ericson and Pakes' model. The new entries adjust their sizes to the industry core output's minimum efficient scale (MES) level. If the firms do not grow fast, they identify niches to increase their survival probability. In the active learning model, more firms in all industries can enter the market (for all periods) than the market can hold. Pakes and Ericson (1998) reported that the retail industry and the manufacturing industry follow the passive learning model and the active learning model, respectively. The retail cohort revealed that it followed the size distribution of the entire industry over eight years, while the manufacturing cohort revealed that, though it achieved a high growth rate, it still had a discrepancy from the size distribution of the entire industry after the same period of years. The cause to the discrepancy is that the manufacturing aggregate is less homogeneous compared to the retailing aggregate.

Other evolutionary theories

Audretsch (1995) expanded Jovanovic's (1982) theoretical research from the evolutionary perspective. It emphasized the inter-industry difference of the survival possibilities of new firms. Audretsch (1995) argues that both new firms/start-ups and large incumbent firms contribute to the economic development, although not in all industries. To explain the industry heterogeneity in relation to the new entrant's evolution of the size distribution, Audretsch (1995) separates the routinized regime from the opposite entrepreneurial regime to see if it is favorable to the innovative entry or less favorable to the existing firm's innovative activity. As a result, according to "growth regimes," it is maintained that in some industries, small firms have the innovative advantages and have the entrepreneurial regime, while in other industries, large enterprises have the innovative advantages and have routinized regimes (Audretsch and Fritsch, 2002). It is argued that this type of size economy and the industry-specific characteristics, such as endowment of the innovative capabilities, make a meaningful influence on the new firm's entry, exit, and survival possibility.

For example, in the industry with the characteristics of a high MES level, the smaller firms have higher costs, and thus they have a higher likelihood to be expelled from the market within a short period of time in the beginning. Therefore, the most efficient new firms survive and grow, while the rests are exposed to the risk of being expelled from the market. In this case, the appearance of firms with higher potential than the firms with the long-term survival possibility can cause shakeout (Klepper and Miller, 1995). The shakeout occurring at a certain time can influence the firm's long-run size distribution within the same industry.

On the other hand, in an industry with a low MES level, the firm's survival possibility is not related to growth capability. This perspective implies that the industry- and firm-specific factors influence the firm size's convergence of lognormal distribution; in industries where smaller entrants have the innovative advantage, the convergence speed will be faster, and in industries where the existing firms have the innovative advantages, the convergence speed will be slower.

A population of firms cannot represent the optimized individual firms. Instead, the significant heterogeneity of firms is recognized. Therefore, the firms with high productivity co-exist with the firms with low productivity in the same industry. However, not all firms belonging to the same industry grow or diminish. Resources are assigned to more productive firms and the less productive firms are expelled. The evolutionary theory follows the bounded rationality, and the firm's future cannot be predicted based on the rationality. Depending on the involvement of luck or will, the firm's future can be changed. As a result, firms cannot decide the investment by deriving the future value from the current value. Instead, the investment is determined by the current financial performance. The mechanism of the evolutionary theory is "selection via differential growth." It follows Fisher's fundamental equation[5]:

$$\delta x_i = \alpha x_i (F_i - \bar{F}) . \qquad \text{Eq. (12)}$$

where δ means infinitesimal interval $(t, t+\delta t)$, and x_i represents firm i's market share. F_i is the 'fitness' of the target firm for consideration and is measured in the same level with the financial performance or relative productivity. $\bar{F}$ refers to the population's average fitness. There are not many empirical analytical studies concerning this. It is known that return rate and productivity rate are independent of the firm's growth (Coad,

[5] Coad (2009)'s writing form was used.

2007) and that financial performance is not a factor determining firm's growth (Coad, 2009).

Fitness means that profitability and productivity are good. However, its empirical analysis is not conclusive. The general conclusion is that, in reality, the sales growth is independent of profitability. Therefore, the fitness plays a clear role as an indicator of profitability and productivity, though product quality or cost level may seem to play the role of indicators (Coad, 2009).

The niche strategy, which is the representative characteristics of the population ecology, does not consider the firm-specific factors and is applicable to all organizations; however, it cannot be controlled by firms. Thus, it is not very helpful in terms of firm's strategy. In particular, because "niche" refers to a specific industry (e.g. automobile industry, bio industry, etc.), it is necessary to have the life-history data for the population. Therefore, the main interest is in investigating the organizations' birth rate and death rate and seeing the effects of the population and environment on the organizations' performance.

Neoclassical literature states that firms invest as long as it is perfectly rational and can increase the firm's long-term performance; however, the imperfectness of the actual financial system causes problems. On the contrary, evolutionary economics rules out the excessive rationality and maintains that firms are heterogeneous and have limited rationality and, therefore, that not all firms grow.

It is known that productivity has little correlation with firm growth. Some firms with high productivity reduce their size, and other firms with high productivity increase their size. It has been reported that many empirical studies have met with difficulties in revealing the relation between productivity and firm growth (Bartelsman and Doms, 2000; Bottazzi et al., 2008).

2.3.6 Criticism of evolutionary growth theory

The efforts to consider the firm's characteristics and to discuss the firm's growth beyond its scale are called "learning by doing." As for the initial learning by doing, the learning curve is generalized as the Boston Consulting Group's experience curve. The basic idea is that the production average price is not so much dependent on firm's output size as it is reducing logarithmically according to the firm's past output accumulation. The learning by doing concept received interest from business management and economists; however, it has a limitation in explaining the firm's growth model. That is, relatively small firms have less accumulated output, and thus, big firms are always in the more favorable position. Because bigger firms follow the learning curve more faithfully, they are always more likely to grow. In addition, it reaches the invalid logic that if the sizes of the firms are the same, the accumulated outputs by learning by doing are the same. Therefore, it is necessary to develop a proxy variable to measure the R&Cs accumulated through the learning by doing instead of the firm's size or age.

The model of the evolution of industry suggested by Jovanovic (1982) conforms also to stochastic growth. In his model, individual firms' cost curves are randomly distributed and are subject to firm-specific shocks. The firms experiencing favorable shocks grow, and those that do not diminish or fail. Jovanovic's model shows that the smaller firms have higher growth/failure rates at the same time compared to those of the bigger firms. If his theory is correct, because the expelled firms are excluded from the target in the empirical analysis, it is likely that the relatively small firms' growth rate is overestimated. Thus, it may be difficult to explain the firm's evolution accurately.

Evolutionary theories argue that the successful firm's growth continues over time. That is, the growth in the consecutive periods has the positive serial correlation, and the older firms grow faster than the younger firms because older firms have more accumulated performance and more opportunities for learning and experience. However, the actual empirical analysis shows the opposite result from this. Hart and Oulton (1998) reported that there is a negative relationship between age and the growth of the surviving firms. Such a negative effect of age on growth does not match with the learning by doing model.

2.4 Implications

The firm's growth theory has been reviewed, from classical production function to the endogenous growth, the evolutionary economics theory, and active/passive learning models. Various causes and results in relation to the firm's growth have introduced through many empirical analyses. The following issues are generally recognized in relation to firm growth.

Firm growth has a close relationship with survival (Evans, 1987b; Hall, 1987). There is a positive correlation between a firm's growth and its survival rate, meaning that the firms with continuous growth have a higher likelihood of survival. Moreover, a firm's growth causes increase in employment. In other words, a firm's growth can be explained by the newly created employment, which is newly created or disappeared during a certain period of time. In addition, the firm's growth increases innovative capability and supports the technological change (Pagano and Schivardi, 2003). Firms need to develop new or more efficient technology to survive in the intensively competitive environment. Thus, it is important for the firm to seek growth through innovative activities. In addition, it is known that more efficient firms grow faster, which also increases the size of the firm. On the other hand, this means that the less efficient firms reduce in size and may exit from the market. The endogenous growth theory offers a good explanation of this phenomenon.

Recent research shows that there is a negative correlation between the size of the initial firm and the post-entry rate of growth in terms of the firm's growth. As for the new firms, growth rate has a negative correlation with initial sizes only during their infancy (Lotti et al., 2001). Recent research also proves that Gibrat's law is not valid because the firm should reach a certain size in order to have a higher survival chance. However, it also explains that, the growth pattern of the entrants is not so different from that of the entire industry after a certain period of time.

The common factor of the stylized fact is to explain the firm's growth with its size or age effect rather than firm's activities, such as experiences or efforts. This is because of the following two characteristics. First, the unobserved heterogeneity value, such as experience or effort, in the growth model cannot be discussed sufficiently due to the difficulty of collecting data. Therefore, the firm's growth has been explained through the values that have been known for decades, such as the size and age of the firm. Those values are also easy to collect. Second, the firm's particular efforts or routines are not sufficiently reflected in the knowledge stock.

The resources and capabilities should be considered for the firm's unobserved heterogeneity

The existing theories and empirical analyses on the firm's growth focus on the firm's size, age, and innovative activity. Even though the organizational ecology or the evolutionary economics argue that firm's growth and survival are influenced by the individual firm's R&Cs, only the firm's size, age, or R&D investment are used to study firm growth. A firm's R&Cs are accumulated from the experiences and the efforts through learning by doing. The reason that the firm's R&Cs are not counted in the empirical analysis of the firm's growth is that it is difficult to collect data on individual firms' specific activities. Another reason is that the measurable data are objectively limited to the firm's sales, asset size, the number of employees, the number of patents, or R&D investment cost, and so on.

Understanding the firm's growth recognized macroscopically can be beneficial to policy-makers who seek to increase the efficiency and the influence of the public policy. However, it is not so beneficial to managers, who seek to increase their firm's actual growth rate and strengthen its competitiveness. This is because the size and the age cannot reflect the generation/evolution processes of the individual firm's unique R&Cs. In addition, they are not variables that the firm's manager can control.

In particular, it is more difficult to collect data on smaller and younger firms. As for the new firms, since their history is short and the fluctuation of financial performance is relatively larger than that of pre-existing firms, it is not easy to measure the firm's growth by the size, age and financial performance data. The newly established firm's growth is, rather, influenced by the type of R&Cs inherited from its parent firm or the degree of its experience and efforts to adapt in its new environment.

The individual firm's unique experience, efforts, and routine should be reflected in the growth model.

A firm's internal capabilities cannot be understood by its external scale of size. The R&Cs or the knowledge stock that the firm owns can explain the current level of the firm; however, these factors are not sufficient to determine whether the speed of the firm's growth will be increased or decreased in the future. The firms with high learning capabilities can generate higher productivity and efficiency, even if it they the same experiences and efforts as their counterparts. In addition, depending on the type of routines, the firm's desired direction for growth varies.

To apply these ideas to growth theory, the knowledge stock in the endogenous growth theory should be extended to the concept including the efforts and routine. The firm's effort to obtain capabilities and distinctive routines can produce different growth rates, although it is true that the stock of distinctive resources can also influence the firm's growth rate.

To make a clear measurement of the individual firm's differentiated capability and growth efforts, it is necessary to obtain relevant data. Furthermore, to achieve accurate estimation of the relationship between the firm's growth and the firm's characteristics (specifically on its capability and growth efforts), the current growth theory and growth models should be improved. To fully understand the firm's growth, it is important to detect the firm's internal/external characteristics.

Therefore, the criticism of the existing growth models as the function of production and firm size has been discussed, and the alternative idea has been suggested. In the present research, the impact on firm's growth is analyzed by assuming that the unobserved heterogeneity, such as R&Cs, is produced and developed through pre-entry experiences and post-entry efforts. Specifically, this research assumes that the type of a firm's initial post-entry efforts effects would cause differences between short-term performance and long-term performance. This research also analyses whether the firm's post-entry effort can create routines and whether these routines can influence future performance.

Chapter 3. Literature Review of Resources and Capabilities

3.1 Basic concept of theoretical perspectives

"Resources" are generally categorized as tangible assets and intangible assets. Examples of tangible assets include financial resources, capital equipment, buildings, land, and so on. Intangible assets include corporate culture, routines, technical capital (e.g. patents), reputation, brands, employee loyalty, networks, and so on. One of the most comprehensive definitions is proposed by Barney (1991), who defines resources as all assets, capabilities, organizational processes, firm attributes, information, and knowledge, among other elements, controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness. While resources are stocks of available factors that a firm owns or controls, including both physical and human assets, "capabilities" are the processes by which firms control resources when attempting to achieve desired results (Amit and Schoemaker, 1993).

An understanding of firm growth and how to optimally use R&Cs to that end has been a central theme in economic theory. However, the treatment of R&Cs in economic theory has, at times, been problematic. For example, in general equilibrium theory (the neo-classical microeconomic theory), it is posited that R&Cs are homogeneous, information is perfectly available and evenly distributed, profit maximization the central goal, and an equilibrium level of output guides production decisions. Clearly, general equilibrium theory was deficient in that it failed to properly consider the internal operations of firms. For these reasons, there were several early and notable attempts to break away from the general equilibrium model (Darroch, 2005).

Firm-specific R&Cs derived from different experiences and efforts clearly have a strong influence on a firm's growths. Thus, the present research aims to examine the effects of the innate/acquired R&Cs on the growth of new firms from the perspective of nature/nurture, respectively. The core theories used to explain this are organization ecology and evolutionary economics. The resource-based view combines these two theories and connects the R&Cs to the growth of firms (Fortune and Mitchell, 2012). Thus, these three theoretical elements are reviewed in the present chapter.

Table 1. Descriptions of resources and capabilites

	Description
R&Cs	· Not limited to buildings or cash but including the creation of new value with the effective combination of management resources that firms have (Penrose, 1959) · Divided into three broad categories: Physical and human and organizational (Barney, 1991)
Resources vs. Capabilities	· Subsequent research has distinguished resources from capabilities in more detail (Amit & Schoemaker, 1993) – Resources are assets that are either owned or controlled by a firm – Capabilities refer to a firm′s ability to exploit and combine resources, through organizational routines, in order to accomplish its targets.
Pre-entry R&Cs	· General sorts of R&Cs along two dimensions in analysis of market entry (Helfat & Lieberman, 2002): – Core vs. complementary R&Cs – Specialized vs. generalized R&Cs

3.1.1 **Organization ecology perspective on pre-entry resources and capabilities**

Organization ecology was proposed in the late 1970s by Hannan and Freeman. The firms in a single industry are viewed as one "population" of organizations, and the theory explains the diversity and variation of the interactions within a population. Therefore, organization ecology is not intended to examine information on concerning individual organizations; rather, it collects the information on all the organizations within a population, and thereby removes the selection bias in order to consider the diversity of the population.

Organization ecology emphasizes how the environment selects organizations for growth rather than how organizations adapt to the environment (Hannan and Carroll, 1992). This logic is the same as in biological evolutionary theory in that only the firms that are well adapted to the new environment can survive. Organization ecology posits that certain organizations are doomed by the environment to fail due to their structural inertia (Hannan and Freeman, 1989). The organizations' inertia prevents organizations from being equipped with the flexible strategies and structures necessary to fit to the new environment and thus, organizations customized to the previous environment decline, while those with strategies and structures appropriate to the new environment newly thrive (Carroll and Hannan, 2000). This perspective considers the changes in the organizational generations in terms of preferential selection rather than innovation.

In the case of new firms, structural inertia comes from pre-entry experience. The pre-entry experience contributes to the creation of the inherited R&Cs. When the inherited R&Cs of new firms are well-suited to the existing environment, the survival rate of these firm increases, and these structural inertias affect the future growth of firms. Thus, the organization ecology perspective provides a useful theoretical background for understanding the effect of the pre-entry experience on firm growth.

New firms tend to be influenced initially by the environment because of the liability of newness (Freeman et al., 1983). To be selected for success by the environment when established, the firms need to overcome this liability. To do so, it is essential to understand the environment of the market and the population at the firm's inception. To understand the effects of the population, it is necessary to look into the effects of the population density on the firms' survival. In dense populations, the competition would be fierce and firms would be eliminated easily (Carroll and Hannan, 2000; Hannan and Carroll, 1992). Conversely, low density means less competition; thus, firms entering the market at this time have a high rate of survival. If entering a market with high density, new firms have lesser networks than established firms, and it is difficult for them to achieve a significant market share (Barnett, 2008; Baum and Ingram, 1998; Carroll and Hannan, 2000).

Organization ecology focuses on the research on the population rather than on individual firms. The main argument is that the characteristics of the environment determines the survival of the firm. Therefore, the relevant empirical research is mostly concerned with the formation of firms (Carroll and Khessina, 2005; Delacroix and Carroll, 1983; Kuilman and Li, 2006) or the mortality process of organizations (Carroll, 1983; Carroll and Delacroix, 1982; Freeman et al., 1983; Hannan and Carroll, 1992; Hannan and Freeman, 1989).

In addition, organization ecology considers size and age as important factors for the growth and survival of firms (Ranger-Moore, 1997). Liability of newness (Freeman et al., 1983) and liability of adolescence theory (Fichman and Levinthal, 1991) attracted attentions because how new firms' handicaps in terms of size and age affect the mortality rate of firms was of central interest within organization ecology.

Recently, Oertel and Walgenbach (2012) have criticized the existing organization ecology research for focusing on large organizations, emphasizing the small/medium-sized firms and considering governance structure of organizations, population density, and legitimacy as the crucial success factors for organizations (Simon and Peter, 2009). In addition, organization ecology examines the effects of the partner's elimination on the mortality of the organization (Oertel and Walgenbach, 2012) as well as the effects of the early state of new firms on the population density and the growing process of the new organizations (Carroll and Hannan, 2000). The concepts of density and legitimacy are usually measured as correlated with the population density item (Carroll and Hannan, 2000; Hannan and Carroll, 1992). When organizations lack legitimacy, the proper licenses, capital, and qualified employees cannot be secured, and the survival rate declines (Sine et al., 2007). New organizations are considered to have low liability of newness because of the lack of trust and legitimacy, and it is believed that the legitimacy increases when the reputation and network are improved. Since organization ecology posits that structural inertia prevents adaptation, the selection of new firms by the environment in the beginning depends on the R&Cs that the new firms have when they enter the market. Therefore, organization ecology provides an important theoretical background for understanding the effects of inherited R&Cs.

As time passes, the issue of adapting to the environment becomes more crucial than that of being selected by the environment, as firms characteristics develop. Thus, the organization ecology perspective of interpreting firms' dynamic patterns solely in terms of age and size has its limits. Depending on the firms' states, the effects of the population density can be different. For example, a high density of big firms does not have any impacts on small firms. This is because big firms do not see the small firms as their competitors. Conversely, a high density of small firms can be no threat to big firms. As shown before, in the situation where not all the firms have the same states, the influence of the environment lessens, and firms grow and adapt to the environment, it would be more fruitful to examine the growth of firms from the perspective of evolutionary economics.

3.1.2 Evolutionary economics perspective on post-entry resources and capabilities

Evolutionary economics considers R&Cs in a more dynamic way. It considers the heterogeneity of the firm and how it develops through time, and thus it is effective for studying nurtured R&Cs.

Nelson and Winter (1982), the representative scholars of evolutionary theory, introduced the concept of ‘routine’ as the underlying organization of a firm, thus being analogous to human genes. In terms of the introduction of the firms’ innovative activities into the perspective; however, the interpretation of the firms’ innovation and R&D activities as analogous to biological variations is a new perspective. While explaining the firm’s economic phenomenon by using the biological mechanism, Nelson and Winter (1982) consider that firms retain a knowledge base and that this is path dependent. The knowledge base can be explained by the concept of routine, and through this routine, the firms' capabilities are explained, and through decision-making process, the growth of firms is explained. Thus, their approach is meaningful to view the interaction between firms and environment in a dynamic perspective. A new firm's pre-entry experience is the start of this interaction, and the experience after this – that is, post-entry effort – is when the nurturing of R&Cs starts.

Evolutionary economics sees that firms produce their output through their complicated production routines, including their specialized resources accumulated over a long period. This becomes their competitive advantage and a factor determining their future strategy's path (Dosi, 2000). New firms' post-entry effort can become the most important aspect of the initial stage, newly forming the routines. If this this secures their competitive advantage, the newly nurtured R&Cs as well as their inherited R&Cs will positively affect the future performance of firms.

The phenomenon that evolutionary economics focuses on is the process when the new firm or new routine is created. This can be referred to as variation, and in the situation where firms are not satisfied with the present status and do not have complete rationality, firms seeking future development seems a logical strategy. This process of searching for new development is explained with the intensive search and extensive search by Levinthal and March (1981). This explains firms' state well as a basis for how to grow the existing businesses and how to secure new growing force. March's argument also focuses on the R&Cs and the utilization of the core capabilities, similarly to the theories explained before. In local exploitation, to increase the short-term effects, firms utilize their R&Cs in the areas that firms do well in, and the evolutionary process remains bound by this strategy. To go to the new area. as in the case of entirely extensive exploration, innovative efforts are necessary, requiring appropriate R&Cs.

As for the new firms, if the decision of whether to focus on local exploitation or extensive exploration in the process of making the initial new routine affects the firms' long-term growth as well as short-term growth, it should be a significant consideration in management strategies. If research on the firms' post-entry effort or the situation of the nurtured R&Cs will tell whether the firm is stability-oriented or challenge-oriented, and also if these activities affect long-term performances as well as short-term performances, it can demonstrate that firms' initial experiences create the nurtured R&Cs and that these continue to develop and affect the long-term growth. This will contribute to the elaboration of the evolutionary economics theory. Since the individual nurtured R&Cs due to the post-entry effort differ between firms, the resource-based view on the R&Cs should be understood in terms of the idiosyncratic firm-level (Fortune and Mitchell, 2012).

3.1.3 The resources-based view on pre-entry and post-entry resources and capabilities

The resources-based view in relation to the firm' s performance can be compared to the industry organization theory. Firms' performances have been discussed with the concept of distinctive competence (Selznick, 1957). The SWOT analysis that firms continue to use was defined by Andrews (1971): the strengths and weaknesses of firms are defined by how firms respond to the opportunities and threats from the environments around the firms. This insight prompted research into firms' differences in performances based on the separation of the external environment and firms' internal competence.

This trend directed the interest toward the industrial environment rather than the firms' internal competence in the 1980s with the industrial structural analysis method, explaining the firms' performance through the analysis method derived from industrial organization theory and empirical research. However, industrial organization theory is limited. It cannot provide the answer to the question of the differences in firms' performances when each firm analyzes the industry precisely, sets and executes the proper strategies, and accumulates the necessary R&Cs. The reason is that industrial organization theory analyzes what firms enter the market promptly with the precise judgment and how suitable firms' structures are for the applicable industry; thus, it does not explain the differences of the performances made in the same condition. That is, the industrial organization theory has the assumption that all firms are fundamentally the same based on the competition strategy theory. However, the resource-based view is the opposite to this approach.

The resource-based view was used first by Penrose in 1959, and after Wernerfelt (1984) introduced it in the strategic management area, it developed very fast in the late 1980s. Contrasting from the industrial organization theory, which judges the industry's attractiveness, the resource-based view provides an answer to the question of which individual firms are likely to succeed in the industry. In the process of selecting the right industry for the firm, the resource-based view emphasizes the analysis of the firm’s internal R&Cs rather than the external environment. Therefore, the important factors for firms’ performances are selecting the right industry to enter (i.e., that where the firm can make use the best of its R&Cs and to continue to secure more R&Cs than other firms in the industry). It is meaningful to consider the connection between selection and adaptation from the perspectives of organization ecology and evolutionary economics applied to R&Cs.

The R&Cs that Penrose (1959) mentioned are not limited to buildings or cash but include the creation of new value with the effective combination of available management resources. They also include new values, such as experience and learning, that can be created through the interactions between existent R&Cs in the firms. That is, R&Cs can be combined with other productive factors in the firm to create experience and learning that assists with the growth of firms. This emphasizes the importance of nurtured R&Cs. Since Hamel and Prahalad (1990) used the concept of core competence in the late 1990s, the recognized scope of R&Cs has extended, and 20 years later it is still widely used in the firm’s for setting management strategies.

Either in the analysis of the firms’ strength and weakness in Andrews’ SWOT analysis or in the selection of a preferable industry fit to the firm’s competitiveness in the industrial organization theory, the firm’s R&Cs takes precedence. In addition, for the continuous growth of the firms, it should be carefully observed how pre-existing R&Cs develops or declines through time. The problem is that it is not easy to measure and judge R&Cs: markets are uncertain, and firms' R&Cs are complex and diverse.

Barney (1986) states that the uncertainty of the productive component market highlights competitive advantage and that if the R&Cs that create the competitive advantages, such as technology and brand, can be purchased easily in the component market, such competitive advantages will disappear easily (Barney, 1986). Therefore, it was emphasized that to create the sustainable competitive advantages, the R&Cs to make the competitive advantages should not be easily secured or copied. Dierickx and Cool (1989) state that the fundamental reason why the R&Cs are difficult to copy lies in the accumulation process of individual R&Cs, which helps to understand the concept of experience or learning (Dierickx and Cool, 1989). Their argument prompts the use of knowledge-based resource and organizational learning in explaining R&Cs. Grant (1991) states that learning through many repetitions is required for R&Cs to become core competences. The core competences used widely in similar industries are the accumulated knowledge, learning, and experience in the firm. Teece et al. (1997), on the basis that a firm’s core competence is created through the long interactions between the firm’s R&Cs, conducted a research on how these R&Cs are accumulated.

R&Cs are divided into physical resources and human resources (Penrose, 1959), and the human resources, compared to physical resources such as buildings, machines, or cash, can be more easily combined with other resources and create new knowledge or experience and play more important roles in the growth of the firm. In particular, human resources are very important because they are intangible resources and, at the same time, through experience and learning, become the main agent to produce other R&Cs. In the late 1990s, the emphasis was placed on the intangible (or knowledge) resources among R&Cs, because the physical resources at that time, such as buildings, machines, or cash, were easily secured and the trade cost was relatively low. However, the latest technical difficulty is due to the more rapid obsolescence of machines, and as the products reflecting the firm-specific idiosyncrasy appear, it is known that the factories and machines with the firm' s production technology knowhow determine the product' s competitiveness, and physical resources are as important as intangible resources.

Fixed R&Cs do not continue to bring positive effects (Helfat and Peteraf, 2003). The successful R&Cs in the evolutionary process of firms can rapidly become causes of failure. Therefore, the continuous observation on the R&Cs or the core competence is required. However, they are difficult to measure directly. The identification of their dynamics, when they appear or disappear, is challenging. Little research has been conducted on how the R&Cs are created in the beginning period of firms and how their effects continue. For example, if firms have a certain period of history, because their various experiences affect each other and are entangled, it is difficult to measure which R&Cs affect which aspects of a firm's performance. Therefore, while most of the research conducted considers the long accumulation process of R&Cs important, in reality, the problems of measuring prevent the reliable identification of dynamics of the creation of resources and the accumulation process.

Therefore, to find out the nature/nurture of the R&Cs, the most effective way is to focus on the period immediately before and the establishment of new firms.

3.1.4 Comparison of perspectives on new firms: Convergence and differences

The commonality between organization ecology and evolutionary economics in the perspective of new firms is the concept of selection (Durand, 2001). Organization ecology maintains that to increase the survival rate of new firms, the organization structure should be accountable and reliable enough to be selected by the environment (Hannan and Freeman, 1984), and the niche strategies appropriate for the environment can assist the selection (Carroll, 1985). Evolutionary economics maintains that firms should have the innovation power to have their own idiosyncrasy and make this process a good routine, which drive long-term performance through the process of variation–selection–retention (Campbell, 1965). The current trend in the literature is to interpret the selection as adaption (Lewin and Volberda, 1999).

The biggest differences between organization ecology and evolutionary economics in terms of new firms are the main agency of the selection and the level of analysis. The organization ecology considers the target of analysis as the population of organization and the evolutionary economics considers it as the firms and routines; thus, the direction of selection is external selection and internal selection, respectively (Durand, 2001).

New firms require the application of both of these theoretical perspectives because the important aspect from each theory occurs in the new firms at the same time. The issue of selection from the environment affects the early survival rate of new firms, and the adaption to the environment is the start of the routines that drive the future growth of the firm. Based on the created routine, the firms will continue to evolve and, as Levinthal and March (1993) argue, the search routine of exploration/exploitation will determine the competitiveness and the growth of the firms in the future.

3.1.5 Empirical results of previous firm growth studies

Before the investigation into the effects of the R&Cs on the firms' performance, it is necessary to investigate how the growth of the representative firms has been researched to date.

Economics theories show interest in the relationship between the firm's profitability or productivity and the firm's growth, as this relationship has important implications in allocating scarce resources.

The expansion of firms is equal to the growth of firms, and the reallocation of the scarce resources is necessary for efficient production in the active development of the industry. Intensive research was conducted on the relationship between productivity and firm growth in addition to the profit; thus, the profit and the productivity are the indicators of the firm's performance and become the major interest. Theorists argue that the firms with high performance take the re-investment of the profit in the firm's growth for granted and more efficient firms end up growing more. However, the proofs of the research show that the relationship between firm performance and firm growth was not as positive as expected or even was neutral (Coad, 2009).

Many empirical studies have been conducted on the effects of innovation on firm growth in addition to those concerning profit and productivity. Innovation is the process of producing more advanced output by using the input more effectively; in the relationship between innovation and firm growth, firm growth can be divided into employment growth and sales growth. In this case, employment growth signifies input and sales growth signifies output (Coad, 2009). Management strategies pay attention to the relationship between innovation and sales growth or profit growth, and the economic or policy strategies pay attention to the relationship between innovation and employment growth.

It is generally argued that sales growth has a positive relationship with innovation. However, it is difficult to prove the relationship between innovation and sales growth empirically. This is because a certain time lag is required to see the result of the innovation in the firm’s performance; in practice, while the innovative ideas are implemented as business by going through the middle-process of product innovation or process innovation, which are subject to a rate of failure, the final success rate would be not be high. Therefore, the research result demonstrate that innovation is more effective in a few fast-growing firms rather than in the average firms – that is, it being effective in the higher performers explains the relationship between innovation and sales growth very well (Coad and Rao, 2008). In the firm's growth, employment growth should be understood by the categories of innovations. Innovation is divided into product innovation and process innovation, and the production innovation has a positive relationship with employment growth. However, concerning process innovation, as the efficiency increases, the number of employee decreases, and recent studies have shown that it has a negative or unclear relationship with employment growth (Hall et al., 2008).

In addition, the firm's growth is affected by age, size, competition among firms, characteristics of the entrepreneur, and so on (Coad, 2009). A firm's size and age have a very close relationship, and it is generally known that age and size have negative relationships with firm growth. Research findings have demonstrated that for the first several years, they continue to have the reverse relationship, and only after a certain age do they come to have a positive relationship (Arne and Mulu, 2007). The competition among firms has partial impacts on the firm's growth; however, this is low compared to the impacts of other factors (Geroski and Gugler, 2004). In reality, new firms are generally small-sized, and if they enter some competitions they tend to lose and exit. It is known that among the entrepreneur's characteristics, human capital (university degrees) provides positive effects on the firm's growth (Almus, 2002; Robson and Obeng, 2008), and the founder's education and experiences contribute to the firm's growth.

Finally, in terms of the relation between the industry's characteristics and the firm's growth, since the high-tech industry has advanced technologies and new products, the firm's growth rate is high. Therefore, it is recognized that firm growth has a lot to do with the industry regime. In particular, the organization ecology emphasizes the industry-specific factor.

As shown in Table 3, empirical analysis of firm growth has been conducted on the areas that are easy to measure, such as profit, productivity, innovation, age, size, and so on. This is analogous to if the success of human activities is measured as wage growth, the research would look at what firm to go to, education level, age, and so on. Therefore, there is a fundamental departure from the research’ s purpose. The reason for the wage increase can be directly explained by the job and the education level; however, the focus in the present study, in this analogy, would be whether the person’ s talent to finish the education level and to enter that firm is inherited from the parents or nurtured later through various experiences.

Table 2. Previous firm growth and survival studies using organization ecology theory and evolutionary theory

	Key variables	Previous studies
Organization Ecology Theory	Mortality process of organization	· Carroll and Delacroix, 1982; Carroll, 1983; Freeman et al., 1983; Hannan and Freeman, 1989; Hannan and Carroll, 1992)
	Survival of organization	· Hannan and Freeman, 1984
	Formation of companies	· Delacroix and Carroll, 1983; Carroll and Khessina, 2005; Kuilman and Li, 2006
	Innovation on firm survival	· Cefis and Marsili, 2006
	Age and size on firm survival	· Cefis and Marsili, 2006; Oertel and Walgenbach, 2012; Ranger-Moore, 1997
	Legitimacy effect on survival	· Sine et al., 2007; Carroll and Hannan, 2000; Hannan and Carroll, 1992
	Change of organization	· Carroll, 1983; Haveman, 1992; Oertel and Walgenbach, 2012
	Density of a population of organizations	· Hannan and Freeman, 1988; Barnett and McKendrick, 2004; Barnett, 2008
Evolutionary Economics Theory	Firm growth in terms of investment	· Nelson and Winter, 1882
	Inter-firm competition	· Geroski and Gugler, 2004
	Innovation and firm growth rate	· Corsino and Gabriele, 2011

Table 3. Empirical results of previous firm growth studies

Variables	Empirical results
Profit, Productivity	· Positive relationship between profitability and both employment and sales growth (Robson and Bennett, 2000) · A positive relationship between productive efficiency and sales growth (Pavcnik, 2002; Sleuwaegen and Goedhuys, 2002) · A firm's profit rate and its subsequent growth rate as entirely independent (Coad, 2007d) · Financial constraints are not a major problem affecting the growth of firms (Santarelli and Vivarelli, 2007) · Among more profitable firms, higher profits are associated with higher levels of investment. Among the least profitable firms, lower profits are associated with higher levels of investment (Guariglia, 2008) · Both productivity and profitability are positively related to the probability of survival (Bellone et al., 2008) · Employment growth and sales growth are followed by growth of R&D expenditure, while growth of profits has little discernible effect on the subsequent growth of R&D (Coad and Rao, 2009)
Innovation	· Positive relationship between R&D activity and sales growth (Del Monte and Papagni, 2003) · A negative relationship between product innovation and the sales growth of manufacturing firms (Freel and Robson, 2004) · A positive influence of innovation on employment growth in four high-tech US manufacturing industries (Coad and Rao, 2007) · Product innovations generally have a positive impact on employment, while the role of process innovations is more ambiguous (Hall et al., 2008) · Product innovation has no significant effect on the sales growth, while having a strong positive effect on sales growth for the fastest-growing firms (Goedhuys and Sleuwaegen, 2008)

Age, Size, Competition, Entrepreneur, etc.	· Growth and age are inversely related only in the first few years after entry and stay constant for most of the age group until it starts to have a positive relation beyond age 50 (Bigsten and Gebreeyesus, 2007) · Unable to detect any significant effect of rival's growth on firm growth (Geroski and Gugler, 2004) · Better- educated founders faced fewer obstacles to expansion (Robson and Obeng, 2008)

Rewriting source of (Coad, 2009)

Table 4. Results in previous studies on *de alio* and *de novo* firms

Authors	Industry	Description
Mitchell, 1994	Medical imaging	· For dissolution, failure rates of *de novo* firms fall faster with age than *de alio* firms with age. For divestiture, exit rates for *de novo* firms rise faster with age. No difference in the effect of size.
Carroll et al.,1996	Automobile	· *De novo* firms with preproduction begin with lower hazard rates than *de alio* firms; however, this falls more slowly as they age. Size has a larger negative effect on hazard rates for *de novo* firms than for *de alio* firms.
Klepper and Simons, 2000	Television	· Survival rates of *de alio* firms are much higher than *de novo* firms in the last period when the industry faced disruptive technology change from color TV and semiconductors. The authors infer that *de alio* firms continued to innovate in the face of new technology, while *de novo* firms did not.
Holbrook et al.,2000	Semiconductors	· While *de novo* firms saw early success with technology, *de alio* firms managed the industry transitions to new technology more successfully than *de novo* entrants.
Klepper, 2002a	Automobile	· Age increases the failure rate for *de novo* firms but not *de alio* firms. Experienced firms generally entered earlier, and see declining hazard with time.
Kelpper, 2002b	Automobile, tires, television, penicillin	· In auto and tires, the study does not find evidence for convergence. In television and penicillin, there is evidence for divergence of the two types.
Bayus and Agarwal, 2007	PC industry	· *De novo* firms failed at higher rates than *de alio* firms after the transition to a new technology regime.

Source: (Chen et al., 2012)

3.1.6 Pre-entry or post-entry resources and capabilities for firm growth

Empirical analysis on firm growth is mainly on profit, productivity, Innovation, Age, Size, Competition, and so on as, as discussed above. These variants are the results of the R&Cs, and the eventual causes to the firm' s growth cannot be explained directly.

If new firms are established with the support from their parent firms and receive a lot of resources, they have high inherited resources. In addition, the multi-aspect firms (or spin-off firms from the parent firms) can have pre-entry experiences in the form of inherited R&Cs. On the other hand, after the establishment, the firms experiencing a lot of post-entry effort by increasing the physical assets or human resources or conducting vigorous R&D activities can increase nurtured R&Cs. The experience described here can be used as the proxy variable of the firm' s capabilities (Kogut and Zander, 1992; Teece et al., 1997; Zollo and Winter, 2002). Firms continue to gain experiences and accumulate learning, and this is linked to the capabilities, which is the basic concept.

The learning model that affects the firm' s performance in the nature/nurture perspective is divided into “passive learning” and “active learning” (Brown and Earle, 2011). The passive learning model uses the logic that the value of the R&Cs that firms have is known through the post result (Jovanovic, 1982). That is, the R&Cs are determined at the same time when firms are established. For example, if the firm' s productivity is fixed and determined only by the inherited capabilities without nurture, the firms' productivity level is already determined, and its location is already determined within the set productivity distribution at the establishment, it does not have any effects on the result (Hopenhayn, 1992). This is the theory focusing on the effects of the inherited R&Cs.

On the other hand, the active learning model uses the logic that if firms intend to increase productivity, they can increase the investment, and it acknowledges the roles of the nurtured R&Cs (Ericson and Pakes, 1995). When the management and policy-makers plan to establish new firms or judge the performance, depending on which model they refer to, the management strategies and policy directions will determine whether they focus on securing the inherited R&Cs or nurtured R&Cs.

3.1.7 **Resources and capabilities through pre-entry experience**

The relationship between the pre-entry experience and knowledge and the long-term performance and survival of firms has been studied extensively (Agarwal et al., 2004; Brüderl et al., 1992; Carroll et al., 1996; Delmar and Shane, 2006; Evans and Leighton, 1989; Fontana and Nesta, 2010; Franco and Filson, 2006; Gimeno et al., 1997; Klepper, 2002a; Klepper and Simons, 2000; Mitchell, 1989). In particular, in the perspective of organization ecology, the research on the *de alio* and *de novo* dichotomy has focused on identifying the effects of the pre-entry experience, and in recent studies effects have been summarized (Chen et al., 2012).

Advanced studies on *de alio* and *de novo* have been conducted with various industries. Numerous studies have been conducted on the U.S. automotive industry

(Carroll et al., 1996), medical device industry (Khessina, 2003; Mitchell, 1994), semi-conductor industry (Hannan and Freeman, 1988), computer-manufacturing industry (Barnett et al., 2003; Swanson, 2002), European automotive industry (Hannan et al., 1998), world optical disk drive industry (Khessina and Carroll, 2008) and so on. While the studies have focused on survival and extinction in the organization ecology perspective, the research extends to entire industries and individual firms.

De alio and *de novo* firms may enter the market together; however, depending on the existence/type of the pre-entry experience, firms start in different organizational types and, eventually, the pattern of innovative activities (Khessina and Carroll, 2008) and marketability (Carroll et al., 1996) are represented differently.

As for *de alio* firms, with the pre-entry experience, since it receives sufficient supports from the existing firms with resources, capital and human labor (Mitchell, 1994), entering the new industry would not be a problem (Levinthal, 1991). The resources, capabilities and brand value received from the previous firms increase the firm’s market share (Klepper and Simons, 2000) and enable the firm to stay in the market for a long time (De Figueiredo and Kyle, 2006). The stable organizational system and manufacturing routines enhance the product’s credibility and increase the success rate in the market (Hannan and Freeman, 1984). In addition, the experience in the market enables the products to be promoted effectively (Nerkar and Roberts, 2004), and the new products relevant to the reputation of its parent firm will have better positions in the promotion when they are first released (Podolny, 1994; Swanson, 2002).

On the other hand, *de novo* firms, without pre-entry experience, have less R&Cs than *de alio* firms; however, numerous studies have demonstrated an advantage in terms of flexible organization and the prompt responsiveness to the change of environment (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firms tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008). It is common sense that innovative firms survive longer in the market (Stavins, 1995). In the case of *de novo* firms, there is no choice but to depend on its own innovative technology from the beginning compared to *de alio* firms. In a sense, since it is naturally free from the technological traces that a parent firm holds, *de novo* firms have an inborn tendency to try innovative technologies. It makes an effort to acquire the best technology and tends to have a business structure fit for the competition in the most advanced technological areas in the chosen market. *De novo* firms can have an advantage of making a prompt response to the technological change over *de alio* firms, which compete in a wide range of areas with various products; however, they are burdened with a higher risk due to not receiving any supports from the existing resources.

The development of *de novo* firms was difficult to interpret in the resource-based view. While it is rational to explain the high survival rate of *de alio* firms with the relatively superior R&Cs in the organization ecology perspective, it is insufficient to explain the success examples of *de novo* firms.

Given this shortcoming, the current research intends to confirm that if *de novo* firms, despite their insufficient inherited R&Cs, add the post-entry efforts through the flexible organization and innovative operation, the nurtured R&Cs can be expected to be created, and the post-entry effort is as important as pre-entry experience to the firm's growth. Pre-entry knowledge and learning affect the growth and survival of new firms as much as pre-entry experience (Dencker et al., 2009). The position of organization ecology is that firms with pre-entry experience or pre-entry knowledge have higher likelihoods of survival in the environment and that these pre-entry R&Cs continue to provide direct assistance in this respect. On the other hand, in the evolutionary economics perspective, since the pre-entry experience and knowledge plays a role in firms acquiring and increasing capabilities to adapt to the new environment, they path-dependent and indirectly affect the firm's long-term performance (Dencker et al., 2009).

The question here is whether the effects of the pre-entry experience are direct or indirect and how long the effects last. However, it is difficult to draw a clear conclusion here. As seen in Table 3, until recently there have been mixed results on the effects of pre-entry experience on the characteristics of *de alio* and *de novo* firms – that is, results of the inherited R&Cs changed over time. Recent studies have maintained that the durability of the effects of pre-entry experience can vary depending on the firm's post-entry effort (Thompson, 2005).

3.1.8 **Resources and capabilities through post-entry effort**

As explained before, pre-entry experience and post-entry efforts are the experiences before/after the establishment of a firm. While the pre-entry experience research has been known widely through the research on *de alio* and *de novo* in organization ecology, unfortunately there have been few researches on the post-entry efforts. After the post-entry, the detailed and special experience linked to the firm’ s performance records cannot be one or two and the interactions among experiences have compound effects on the firm’ s performances. Rather, in evolutionary economics perspective, there have been some arguments that the pre-entry experience has direct effects on the firm’ s performance but also increases the firm’ s learning capability and adaption to the environment and continues to have effects even after the establishment (Dencker et al., 2009; Nelson and Winter, 1982). However, the current research intends to prove that it was the result ignoring the fact that the experience right after the establishment can be the start of the firm’ s routine (Deakins and Freel, 1998).

Reviewing a few available existing researches, the researches dealing with firm’ s initial business activities and experiences analyze how the initial experiences have impacts on the survival of the firm and the short-term performance. Theoretical and positive analyses are available on the impact of experiences such as operating experience (Kim et al., 2009), problem solving experience (Hugo and Garnsey, 2005), success experience (Aldrich, 1999; Cyert and March, 1992), recovery experience (Hambrick and Schecter, 1983) and so on that firms experience in the beginning on the performances. Especially, Deakins and Freel’ s research (1998) explains that the initial activities of a firm affect the learning of a firm organization and the formation of its routine. In the experiences and activities that a business organization undergoes, the firm learns in a method of trial-and-error and it is internalized inside the organization as the firm’s own problem-solving method, response to the change of environment, culture, and so on and becomes a routine (Deakins and Freel, 1998).

New firms will estimate their R&Cs with or without their pre-entry experience (Helfat and Lieberman, 2002), judge whether they fit to the new market environment or not and eventually enters the market. Therefore, pre-entry experience can be the decisive factor on the post-entry effort. Thus, dividing the effects of the post-entry effort and those of the pre-entry experiences can be an important process. That is, the post-entry effort should focus on the firm’s raising of the R&Cs through the process of firm’s learning by doing for a certain period of time right after the establishment. To explain the effects of R&Cs through post-entry effort properly, the operation management should be improved and the activities on capital investment (Thompson, 2001), R&D investment on the manufacturing facilities (Sinclair et al., 2000) and the individual worker’s experience (Lazonick and Brush, 1985) due to the increase of the labor forces should be limited to the early activities of the firms.

The firm’s performance cannot be explained with only one frame; either inherited R&Cs or nurtured R&Cs. However, the argument that both of them made impacts needs still more discussion. Considering the 100-year-old dispute over nature vs. nurture and nurture via nature on the causes of human behavior, the dispute over nature vs. nurture on the growth of firms has just started.

3.2 Research hypothesis

This present research seeks to determine the extent to which the R&Cs are given as an inborn endowment or an acquired ability. The new firm' s pre-entry experience and post-entry effort (instead of the firm size and age) will be discussed to examine how they affect the firm's growth.

New firms' establishment and growth processes are analyzed with the theoretical framework of organization ecology and the evolutionary economics integrated in the perspective of selection and adaptation (Fortune and Mitchell, 2012). In the organization ecology perspective, the effects of the natural/inherited R&Cs on the firm's growth can be explained. Also, in the evolutionary economics perspective, the effects of the nurtured/acquired R&Cs on the firm's growth can be explained in this research. The resource-based view explains how the R&Cs are created through various experiences and also how they explain the firm dynamics, which eventually dictate firms' future growth. Thus, the resource-based view combines and elaborates the organization ecology and evolutionary economic theories. This research places an emphasis on the determination of the firm's growth with the theoretical reasons, and compares the effect of inherited R&Cs and nurtured R&Cs on firm growth.

Do pre-entry R&Cs have long-term effects on the firm's growth?

Some firms begin with sufficient R&Cs (*de alio* firms), while some start the business only with an attraction to the market (*de novo* firms). This raises the question of how the growth of firms with the insufficient R&Cs can be explained. Conversely, how can the failure of firms with sufficient R&Cs be explained?

Many researches on *de alio* and *de novo* firms demonstrate that inherited R&Cs are determined by the pre-entry experience and the survival rate of *de alio* firms is high due to their R&Cs. The problem is that the effects of pre-entry experience change over time. This also means that the characteristics of the organization change as time passes. As for *de alio* firms, the R&Cs have a tendency to generate the side effects of organizational inflexibility and inertia after the initial stage of market entrance. As for *de novo* firms, as their organization is flexible to the environmental changes, the R&Cs can be accumulated, and the speed of product obsolescence slows over time. There is a tendency to catch-up with the rate of *de alio* firms' products (Khessina and Carroll, 2008). Of course, after a certain period of time, *de novo* firms the same difficulty due to the inertia that *de alio* firms face (Carroll et al., 1996).

These results occur because the organization ecology perspective does not consider the firm's distinctiveness, focusing only on the firm's survival and extinction. This is because the various experiences that each firm undergoes following establishment are not reflected. Therefore, the detailed reasons for the change of organizations are not considered. To see more precise effects of the pre-entry experiences (i.e., inherited R&Cs), it is desirable to analyze the growth rate of firms and the performance differences over time rather than the survival rate of firms.

By analyzing the growth rates (and there continuance) of *de alio* and *de novo* firms, a clear conclusion can be obtained as to the effects (and their continuance) of the inherited R&Cs on the growth of firms.

According to the literature, *de alio* firms have resource and capability advantages while *de novo* firms have an organizational flexibility that enables them to adapt to changes in their business environment. However, the research has focused on how these advantages influence their survival, thus ignoring the question of how one group's advantages help them compete with the other group and affect the time-lag changes in their growth pattern. Unfortunately, very little research has been done on these issues. Therefore, this study intends to fill this research gap by investigating the competing dynamics behind the firms' corporate growth and growth patterns.

To do this, the new and renewable energy industry, in which *de alio* and *de novo* firms are evenly distributed and novice producers. These two industrial characteristics can minimize the indirect externalities arising from the industry itself. Therefore, the new and renewable energy industry is an excellent choice for an analysis of the patterns of corporate growth resulting from different entry modes.

From these two, pre-entry and post-entry, R&Cs, which one would have a long-term effect on the growth of a firm?

As for the new firms, , the firms' R&Cs upon market entry are determined depending on the type of pre-entry experience (Helfat and Lieberman, 2002). This determines not only the post-entry performances but also the long-term survival or growth of firms. The appropriate firm is selected to the environment, and will continue to grow. In this case, the firm's growth is dependent on the inherited R&Cs. On the other hand, after entering the market, if the firms continue to develop the R&Cs dynamically by means of the post-entry effort, the learning by doing process, and perform well, they will survive. In this case, the firm's growth is said to be dependent on the nurtured R&Cs. The pre-entry experience and the post-entry effort will be categorized as the nature/nurture of the R&Cs. Furthermore, by comparing and analyzing the effects on the firm's growth in respect to pre-entry experience and post-entry effort, one can determine whether inherited or nurtured R&Cs are more beneficial to the firm's growth. In this case, the post-entry effort generating the nurtured R&Cs should be categorized as a type and should be measured in detail. In addition, by limiting the period of post-entry effort, the compound effect of the R&Cs over time is minimized, and its effect on the future growth of firms can be more clearly identified.

As good habits last long and these habits are eventually linked to performance, the new firm's good routines can influence the evolution process of the firms and finally affect the firms' long-term performance. However, not every post-entry effort is beneficial. It depends on the type of industry and growth rate: higher-growth firms and lower-growth firms.

To prove this, Chapter Five will examine the effects of the pre-entry experience and post-entry efforts in the manufacturing industry concerning the firms' short- and long-term performances. The manufacturing industry can be categorized into high-tech industry and low-tech industry. Since there are enough new/existing firms, the manufacturing industry is proper to compare the pre/post-entry efforts and to categorize the various types of post-entry effort.

Can the arguments of nature vs. nurture on the R&Cs usefully inform managers or policy makers?

The arguments of nature vs. nurture concerning new firms' R&Cs will provide very important implications to the policy makers as well as managers. New firms' entries and exits play very important roles in economic development and the creation of jobs (Stel et al., 2005; Thurik, 2003). Additionally, as seen in Barnett and Burgelman's (1996) research, which analyzes Intel's changing process of strategies from the evolutionary perspective, insight into the internal R&Cs will provide very important execution-ability to the management strategies (Barnett and Burgelman, 1996; Burgelman, 1991). The result of the dispute as to the extent to which the growth of firms is caused by nature or nurture will/should have a significant impact on the strategic judgment of both policy-makers and managers. If the growth of firms is affected mainly by the inherited R&Cs, the new firms must prepare such R&Cs sufficiently before entering to the market.

Furthermore, the start-ups or venture firms that have limited inherited R&Cs or no special technologies should be protected by central policy.

The existing firms would understand that the strategies of diversification or spin-off have a higher success rates rather than the venture investment. On the other hand, if the firm's growth is strongly affected by the nurtured R&Cs, the firms should actively change their existing R&Cs. In addition, they should develop the organizational structure to enable the continuous development of internal capabilities. In particular, the initial period of new firms should place the sufficient efforts on developing their R&Cs and rather than solely or mainly on increasing the size of their firms. The start-ups or venture firms, which show a high possibility to develop their capability, should be supported by relevant policies.

Chapter 4. Growth Pattern of De Alio and De Novo Firms in the New and Renewable Energy Industry

4.1 Introduction

Understanding the factors central to firm success and the sources of corporate growth is an important but difficult task for entrepreneurs and policymakers. A steady stream of diverse arguments on and evidence for firm growth indicates this; in fact, there is no unanimity, even among scholars. Grasping firm growth patterns is difficult, given the lack of information on industries. Making matters worse is the volatile external environment, in which firms frequently enter and exit their industries and where industries are highly sensitive to technological trends.

Understanding corporate growth patterns would be furthered if we could track the history of firm growth from its initial stage, firm entry. Patterns of firm growth and decline are determined by factors such as R&Cs either inherited from parents or earned during pre-entry experience, R&Cs gained through learning by doing, and the firm’s absorptive capacity.

Our research focuses on the growth pattern of two types of market entrants: firms with inherited R&Cs and firms with no inheritance but innovative capabilities and organizational flexibility. To compare the key characteristics of the two entry modes, we conduct an empirical analysis on firms in the new and renewable energy industry, an industry that provides a good fit for our analysis, as both the pre-entry experience and innovative capabilities are important firm assets in this industry. Our classification of market entrants into *de alio* and *de novo* types is driven by whether the firms have those two assets. *De alio* and *de novo* firms both have strengths. *De alio* firms such as spinoffs and diversified companies benefit from R&Cs gained through pre-experience, whereas *de novo* firms such as start-ups and venture businesses enjoy organizational flexibility and innovative capabilities (Helfat and Lieberman, 2002). This study analyzes the growth patterns of the two groups of new and renewable energy firms by comparing their growth rates.

De alio and de novo firm characteristics

De alio and *de novo* firms entering the market together begin as different organizational types and eventually follow different innovation patterns depending on their pre-entry experience (Khessina and Carroll, 2008) and their marketability (Carroll et al., 1996) is represented differently. As *de alio* firms with pre-entry experience receive sufficient support from existing firms with resources, capital, and human labor (Mitchell, 1994), their entry into new industries is not problematic (Levinthal, 1991). The resources, capabilities, and brand value received from the previous firms increases a firm's market share (Klepper and Simons, 2000) and allow it to stay in the market for the long term (De Figueiredo and Kyle, 2006).

Though *de novo* firms without pre-entry experience have fewer R&Cs than *de alio* firms, research has proven that they have the advantage of flexible organization and the capacity to respond to environmental changes promptly (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). *De novo* firms tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008). *De novo* firms that have not inherited resources and capacities from parent firms have no choice but to depend on their own innovative technologies, unlike their *de alio* counterparts. They strive to acquire the best technology and tend to have business structures fit for competition in the most technologically advanced arenas.

Studies on industry dynamics have analyzed how firm survival depends on entry mode (*de alio* vs. *de novo*) in various industries (Carroll et al., 1996; Khessina and Carroll, 2008; Swanson, 2002). This study empirically investigates whether *de alio* or *de novo* firms grow faster and sustain their growth in the new and renewable energy industry.

The new and renewable energy industry is growing rapidly, and its firms' growth is considered more important than their exit and organizational restructuring.

New and renewable energy industry characteristics

Since the 1973-74 oil crisis, the new and renewable energy industry has become one of the most attractive investment destinations in the world. A surge in R&D investment in this sector was expected to continue but began to falter in the 1980s. This infant industry then began to steadily develop in the 1990s (Schilling and Esmundo, 2009).

It is still a promising global market. The IEA (2012) expects that global energy demands will increase by more than 30 percent by 2035, and many have raised environmental concerns over the rapidly increasing consumption of fossil fuels. The IEA (2012) also estimates that the new energy industry has an almost 30 percent share of the global energy mix and that global government subsidies will increase from 88 billion dollars globally in 2011 to nearly 240 billion dollars in 2035 (IEA, 2012).

Market stabilization is still nowhere in sight, despite the global spotlight on and growing investment in this industry. For decades, technology has developed a variety of new and renewable energy sources such as biofuel, solar cell, and wind power. However, this energy industry is still in its infancy and has been falling behind fossil fuels in terms of price competitiveness, being highly dependent on government policies and oil prices. The market landscape has made entrepreneurs hesitant to risk investing in this fledging industry. Against this background, however, wind power had an annual growth rate of 23.7%, and solar photovoltaic grew by 36.1% between 1990 and 2006 (Johnstone et al., 2010). Such high growth rates have suggested a bright future for the new and renewable energy industry. Both companies reaching their growth limits and innovative fledgling firms can seize the opportunities being offered in this sector.

In order to sharpen competitiveness in the new and renewable energy industry, companies should equip themselves not only with R&Cs but also with organizational flexibility and innovative capacity to overcome market uncertainty. Thus, a comparison between the growth patterns of *de alio* and *de novo* firms in this industry will deepen our understanding of firm growth. The new and renewable energy sector has an even distribution between *de alio* and *de novo* entry modes. In an emerging sector like this, *de alio* and *de novo* firms have few significant technological differences, and neither enjoys advantages in an unstable market. These industrial characteristics can minimize the indirect externalities arising from the nature of the industry, allowing us to effectively analyze the firm growth patterns subsequent to different entry modes. Aside from the question of inherited R&Cs, *de alio* and *de novo* entrants compete on an equal footing in the new and renewable energy industry. Therefore, this industry best fits our research goals.

The paper examines two research questions:

(1) Which type of entrance (de alio or de novo) achieves faster sales growth, and

(2) How long does this effect last in the new and renewable energy industry?

We expect that *de alio* firms have higher sales growth rates than *de novo* firms in the early years because the former can begin operating in more favorable conditions due to their inherited R&Cs. As time goes on, however, the gap between *de alio* and *de novo* firms will narrow and finally disappear. In the short term, pre-entry experience's effect on firm growth is stronger than that of innovative capacity and organizational flexibility. In the mid to long term, large *de novo* firms accelerate their growth and eventually catch up with the *de alio* firms. In the longer term, *de novo* firms can acquire R&Cs through learning by doing, at which point *de novo* firms acquire *de alio* status. Therefore, we expect that dividing firms into *de alio* and *de novo* types to compare their growth rates serves no purpose. We perform additional analyses by using a quantile regression to show how the gap between *de alio* and *de novo* firms changes for high-growth firms.

This research is significant in that it relates *de alio* and *de novo* firms' growth to the characteristics of their industry. It analyzes which entry mode (*de alio* or *de novo*) is more advantageous for growth and reveals how long the entry condition can be maintained. For companies considering diversification or establishing new companies for new businesses, this study can assist strategic decision making by indicating the factors that should be emphasized depending on the resources available and the type of organization. This study can also provide policy makers with clues as to whether promotion for diversification or investment is more effective for a start-up firm in a new and growing industry.

The remainder of this paper is organized as follows: in section 4.2, the literature on firm growth and entry modes are reviewed. Section 4.3 explains the research structure and model. And, section 4.5 presents the summary based on the empirical results in section 4.4.

4.2 Previous studies

4.2.1 **Traditional factors in firms' growth**

There are four views of firm growth patterns. One is the resource-based theory, which discusses the effects of retained resources. The second view concerns the effects of dynamic innovative capabilities. The third view analyzes the effects of age and size based on the stylized facts. Last, there is the view that investment in innovation and innovative activities have an influence on firms' growth.

First, the strategic management view on R&Cs is often used to discuss the growth of firms that have already grown to a certain size when they establish their business. The abundant resources and specialized core capabilities of such firms lower their risk in the market and act as leverage for new opportunities. R&Cs such as capital, technology, organizational structure, and knowledge from experience are constantly cumulated and transferred for a firm's continuous growth (Teece and Pisano, 1994). A company properly equipped with R&Cs is able to make gradual innovative actions through organizational routines, but may be handicapped by not being able to respond quickly to sudden environmental changes because of less flexibility because of inertia resulting from the firm's large size (Christensen et al., 2004).

Second, innovative capability refers to a firm's growth in a technology-intensive industry. New entrants are not affected by conventional rules, as they do not have any inherited resources or capabilities. New companies tend to focus on what they do best, relying on their core technology. They can respond quickly to environmental changes because they are small and flexible (Hannan and Freeman, 1984; Haveman, 1992). In the beginning, entrants may take the lead in terms of technology; however, some of them fail because they lack resources, capabilities, brand value, and experience (Bruderl et al., 1992).

Third, a branch of research has linked firm growth to age and size. In the early stage of research, there was conflict between the findings of two studies: one states that larger firms have higher growth rates (Singh and Whittington, 1975), while the other states that younger, smaller firms have higher growth rates (Evans, 1987a). Afterward, (Hart and Oulton, 1996) found that the reverse relationship between a firm's size and growth is valid only for small- and medium-sized enterprises while it is not valid any more for large sized enterprises.

Firms age has been widely used as an essential variable when firm's growth is regressed, implying that older firms achieve lower growth rates (Dunne and Hughes, 1994; Evans, 1987a). As a firm gets older, it faces trade-offs between positive factors such as experience, reputation, track records, and financial trust and negative factors such as inertia, routine, and bureaucracy. Eventually, negative factors overwhelm positive ones in older firms.

Fourth is an innovation achievement. A number of theories identify a positive correlation between company growth and innovation achievements, although many empirical studies have shown non-satisfactory results. Some have reported no relationship between the two (Bottazzi et al., 2001). It may be difficult to clearly define the relationship between innovation and firm growth because only a small number of firms grow within the tent-shaped distribution of the growth rate and because regression analysis finds average trends of population.

These four views do not conflict with one another; they are closely related. The emphasized points in these four growth patterns can be categorized into static and dynamic factors. Size and available resources can be considered as static factors and dynamic capabilities, and innovative activity can be regarded as a dynamic factor. Thus, it is important to consider these static and dynamic factors in studies on firm growth.

This study is intended to determine which of the two market entrants is in a more advantageous position for firm growth in a fledgling industry like the new and renewable energy industry—*de alio* firms born with a silver spoon in their mouth or *de novo* firms born without it but with organizational flexibility and innovative capacity. To answer our research question, we divide market entrants into two subsectors and use variables such as size, age, R&D investment, and profitability as control variables.

4.2.2 **Previous studies on *de alio* and *de novo* firms**

There are several difficulties in analyzing whether a firm with strength in terms of static factors, such as abundant resources, or a firm with strength in terms of dynamic factors, such as organizational flexibility, achieves a higher growth rate. First, it is hard to distinguish whether a company has abundant resources or a flexible organization, and this can change over time. An effective means of distinction could be to categorize entrants as either *de alio* or *de novo*. *De alio* refers to the firm that has their parent company or has experience in other industries, and which become diversified companies or parent spin-offs. *De novo* refers to the firm without a parent company or business experience (Helfat and Lieberman, 2002). *De alio* and *de novo* firms may exhibit differences in their patterns of innovation activity (Khessina and Carroll, 2008) and market achievements (Carroll et al., 1996) because of their different organizational structures.

Prior studies on *de alio* and *de novo* firms have been conducted on various industries, including the semiconductor industry (Hannan and Freeman, 1988), the U.S. automobile industry (Carroll et al., 1996), the European automobile industry (Hannan et al., 1998), the medical equipment industry (Khessina, 2003; Mitchell, 1994), the computer manufacturing industry (Barnett et al., 2003; Swanson, 2002), and the world optical disk drive industry (Khessina and Carroll, 2008).

D*e alio* firms are likely to be exposed to less danger in the early stage because they usually receive sufficient resources, capital, and human resources from their previous companies (Levinthal, 1991; Mitchell, 1994). This heritage from a previous firm includes resources, capabilities, and brand value, and enable *de alio* firms to obtain a higher market share (Klepper and Simons, 2000) and survive longer (De Figueiredo and Kyle, 2006). The stabilized organization structure and production routine enhance consumer trust in products and increase the firm's chances of success (Hannan and Freeman, 1984). Their experience in other markets enables them to more effectively advertise their products (Nerkar and Roberts, 2004), and the wide spectrum of products and reputation of their parent companies are useful when advertising (Podolny, 1994; Swanson, 2002). For these reasons, Carroll et al. (1996) proved that the survival rate of *de alio* firms is higher than that of *de novo* firms at the initial stage in the U.S. automobile industry. In other case, Khessina (2008) stated that the products of *de novo* firms would be withdrawn earlier from the market than those of *de alio* in the world optical disk drive industry.

On the other hand, various empirical studies have shown that *de novo* firms can become more flexible in their organizations and can more quickly respond to environmental changes than *de alio* firms (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firms produce innovative products based on their advanced technology (Khessina, 2003; Khessina and Carroll, 2008). It is common knowledge that innovative firms survive longer (Stavins, 1995). As *de novo* firms do not have any resources or capabilities inherited from a parent company, they must rely on innovative technology. Indeed, they may have an innate tendency to attempt free technology innovation without technical constraint from such a parent company. In many cases, *de novo* firms have business structures designed to acquire the best technological knowledge and compete in the area of the latest technology.

On the other side, *de novo* firms are exposed to greater risk because there is no support available. As is typical of industries with short product cycles, if *de novo* firms lose their reputation, they will tend to disappear from consumers' interest, which makes survival more difficult for them than for *de alio* firms (Khessina and Carroll, 2008).

A common factor between *de alio* and *de novo* firms is that their organizational characteristics change over time. *De alio* firms face side effects based on the stiffness of their organizations and problems of inertia that once contributed to their survival. Similarly, the survival rate of *de novo* firms will converge to that of *de alio* firms as *de novo* firms accumulate R&Cs over time (Khessina and Carroll, 2008). Of course, after a certain period of time, *de novo* firms can suffer from the same inertia problem (Carroll et al., 1996).

In conclusion, previous studies on the survival of *de alio* and *de novo* firms clearly distinguish the advantages and disadvantages of the two entry modes. This study aims to expand the understanding of the effect of entry modes on firms' survival and growth, including whether previous R&Cs or innovative flexibility is more effective for firm growth, and how long such an effect would last.

Table 5 shows characteristics of entrant type and classification of *de alio* and *de novo* (Helfat and Lieberman, 2002).

Table 5. Entrant type and entry modes

Entrant type	Legal relationship of entrant to established firm	Modes of entry	Parent firm ownership	Type
Diversifying entrant	Same legal entity	Internal growth Acquisition	Full	*De alio*
Parent-company venture	Separate legal entity: Founded by established firm	Joint venture Franchise Parent spin-off	Partial	
De novo entrant	Separate legal entity: Founder previously employed by an established firm, No prior employment or financial relationship	New entrepreneurial spin-off, New start-up	None	*De novo*

Source: (Helfat and Lieberman, 2002)

Table 6. The impact factor and proxy variables for firm growth

	Previous studies	Proxy variables
R&Cs	The abundant resources and specialized core capabilities of such firms lower their risk in the market and act as leverage for new opportunities. R&Cs such as capital, technology, organizational structure, and knowledge from experience are constantly cumulated and transferred for a firm's continuous growth	De alio
Innovative capability	New entrants are not affected by conventional rules, as they do not have any inherited resources or capabilities. New companies tend to focus on what they do best, relying on their core technology. They can respond quickly to environmental changes because they are small and flexible	De novo
Size and Age	that larger firms have higher growth rates, while the other states that younger, smaller firms have higher growth rates(Evans, 1987a)(Evans, 1987a). As a firm gets older, it faces trade-offs between positive factors such as experience, reputation, track records, and financial trust and negative factors such as inertia, routine, and bureaucracy.	Sales, Employment Age
Innovation achievement	A number of theories identify a positive correlation between company growth and innovation achievements, although many empirical studies have shown non-satisfactory results.	R&D intensity Profit ratio

4.3 Research design and analysis model

4.3.1 Research questions

This study addresses two questions. First, in regard to firm growth, this study considers whether a *de alio* firm, given the accumulated R&Cs of its parent company, has a relative advantage or disadvantage compared to a *de novo* firm, which possesses innovative products and a flexible organizational structure. In the field of firm demography, which explains firm birth, growth, death, and other related topics demographically, *de alio* and *de novo* studies have focused predominantly on firm survival and the lifespan of products. This study finds another focal strength in that it has expanded relevant studies to firm growth.

Second, this study addresses the question of how long the effect of entry modes on firm growth last. In previous studies, *de alio* and *de novo* studies were conducted under the premise that the influences resulting from the differences in entry modes continue until a company closes. However, in reality, it is likely that the effects of entry modes may become diluted over time, and may even, with ample time, have no significant effect at all. Considerations of the effective length of entry modes differentiate this research from previous studies.

Recent *de alio* and *de novo* research has focused on identifying the effects of pre-entry experience; updates have been released (Agarwal and Helfat, 2009; Chen et al., 2012). However, this study is interested in how these advantages influence firm survival, which overlooks the question of how advantages help one group compete with the other group and how the time lags change in the growth pattern. Unfortunately, very little research has been done on these issues. Therefore, this study intends to fill the research gap by investigating the competing dynamics behind firm growth and growth patterns. To do this, we chose the new and renewable energy industry, in which *de alio* and *de novo* firms are evenly distributed and are both novice producers, industrial characteristics that can minimize the indirect externalities arising from the industry. Therefore, the new and renewable energy industry is an excellent choice for our analysis of the patterns of firm growth resulting from different entry modes.

4.3.2 **Data collection and analysis model**

In this study, data on globally listed companies was collected from the Thomson Reuters Datastream and analyzed through panel analysis. This study was conducted in accordance with the classification criteria provided by FTSE's Industry Classification Benchmark (ICB). Furthermore, firms in the new and renewable energy industry that are included in this study were listed in the "alternative sector" of the ICB; data on 298 companies were available.

The new and renewable energy industry is still in a growth stage, and most small companies' R&D efforts have yet to be commercialized successfully. Facing data limitations, this study confined its analysis to publicly traded firms that produce actual sales in order to compare the sales growth rates of *de alio* and *de novo* firms.

This study collected the data from the lists of globally listed companies provided by Thomson Reuters Datastream. The sample selection bias might have occurred because our data cannot represent all companies in the new and renewable energy industry. When the new and renewable energy industry reaches maturity, the number of firms will be large enough to correct the sample selection bias. This study has this to future research.

For new and renewable energy, the International Patent Classification (IPC) classifies the energy sources into wind, solar, geothermal, ocean, biomass, and waste (Johnstone et al., 2010).

Among these, biofuel has advantages over other fuels. Its extraction from biomass involves relatively simple technology, and it can immediately be used as a liquid transportation fuel. After the 1970 oil crisis, the world turned its eyes to biofuel. Since the 1980s, this energy source has steadily increased its share of the global market mix. Wind power and solar energy are the best fit for a distributed energy model. We can use existing grids to transmit electricity generated from wind power or solar energy and separate devices to transmit electricity from solar energy. Since the 1990s, governments have been competitively subsidizing new energy development, and businesses have accelerated their commercialization efforts. However, there is a long way to go before solar energy can be commercialized, largely due to its weak price competitiveness against fossil fuel despite the considerable cost reduction efforts (Schilling and Esmundo, 2009).

Thus, the sources of new and renewable energy differ in terms of technological development, product shapes, and industrial development. Given this industrial landscape, we divided new and renewable energy into the equipment and fuel subsectors.

The equipment subsector comprises a group of equipment producers efficiently generating electricity from new energy sources; the equipment producers of solar cells, wind power, and fuel cells are good examples.

The fuel subsector includes the producers of alternative fuels such as biomass fuel. In the equipment subsector, firms with a high level of technology have the advantage.

In the equipment subsector, firms are more likely to survive if they have high levels of technology that can efficiently generate electricity; thus, they should have strong product innovation. Meanwhile, using their current infrastructures and fuel production facilities, producers in the fuel subsector can produce and commercialize biofuel immediately if they have the technology to convert biomass to biofuel. Therefore, firms already equipped with fuel facilities and technological expertise can enter the market through diversification and are more likely to survive.

The new and renewable energy industry still requires much technological development. This energy's development strategy includes technological development, efficiency improvements in production, and the introduction of sources of new and renewable energy (Lund, 2007). In the new and renewable energy sector, firm survival depends on whether firms can efficiently generate electricity from new energy sources and develop cheap alternatives to fossil fuels. This industry has the huge potential to replace the existing energy industry. However, considering the external business landscape, where price competitiveness is determined by oil prices, all market entrants in this industry are exposed to a similar level of uncertainty.

Not only has this study carried out a differentiated analysis on *de alio* and *de novo* firms, it has also analyzed the effects caused by the differences in the equipment and fuel subsectors. Using concepts such as innovative technology, appropriability, cumulativeness, and knowledge base, as presented in (Malerba and Orsenigo, 1997), equipment manufacturing industries and fuel production industries can be grouped according to their industrial characteristics, as shown in Table 7. The equipment and fuel subsectors both fall under the category of “new and renewable energy related companies,” but there exist clear distinctions between manufacturing equipment and producing fuel in regard to industrial characteristics. Consequently, the analysis was conducted taking into account the fact that these distinctions may have different influences on *de alio* and *de novo* firms’ growth patterns.

The history and financial information for industries provided by Thomson Reuters was used as the primary data to determine the differences between *de alio* and *de novo* firms and between the equipment and fuel subsectors. For companies for which sufficient information was unavailable, their internet homepages were used as secondary sources. Distinction between *de alio* and *de novo* firms was done through comprehensive consideration of a number of factors, including the existence of a parent company or subsidiary companies, former firm names, firm history at the time of establishment, and the firm’s list of products.

Table 7. Characteristics of the new and renewable energy industry according to the industrial regime

Regime type	Equipment subsector	Fuel subsector
Opportunity for innovation	· For product innovation, it requires the development of materials and equipment simultaneously. · It requires knowledge from a variety of fields. · The success rate of product innovation is not high.	· New knowledge as well as existing fuel production technology can be easily used. · The success rate of process innovation is high.
Appropriability	· A high level of technology is required for product development. · Efforts of innovation and its protection are important. · High appropriability.	· Technology innovation is partially required in the development of fuel. · Process innovation to lower production costs is most important. · Relatively low appropriability.
Cumulativeness	· Product improvements are carried out based on the accumulation of innovation capabilities. · More superior cumulative innovation capabilities allow for an advantage in developing future products.	· There is little variety in the types of products and the process technology is of a low level. · However, the use of accumulated technologies is high.
Knowledge base	· Specialized knowledge corresponding to product characteristics is required.	· General knowledge about fuel production is required.
Major products	· Solar energy, wind energy, fuel cells, etc.	· Biofuels, etc

Ordinarily, a firm's growth rate can be measured according to the growth rates of sales, assets, and number of employees. In the case of the growth rate of assets, tangible assets cannot be a proper proxy for growth in industries where intangible assets play an important role in firm growth. Meanwhile, the growth rate of the number of employees does not require a deflator; this is an advantage. The disadvantage of using the number of employees, however, is that there are too many missing data in the Thomson database, and this number tends to be stagnant for long periods in some firms. In contrast, the growth rate of sales can accurately reflect the long- and short-term changes of firms, and is a commonly used indicator (Coad and Holzl, 2010). Accordingly, this study used the growth rate of sales for a two-year period beginning with the start of the business.

Table 8 explains the variables used in this research.

For the dependent variables, the sales growth rates of firms were used in the form of natural logarithmic function.

Regarding the main independent variables, firms with *do novo* characteristics have "1" as the de_novo variable, and the firms with *de alio* characteristics have a "0" for the de_novo variable. We used the two types of dummy variable that distinguish between *de alio* and *de novo* firms, "equipment subsector," and "fuel subsector," as independent variables. The dummy variable of equipment subsector is "1." Our control variables were age and the profit_ratio (=profit/sales), and R&D intensity. ln_sales is an indicator of the relevance of firm size, and R&D intensity shows how much the companies invested in the industry and how active they were in R&D. We assume that a one-year time lag exists between a firm's growth and the control variables.

All monetary figures were converted to constant 2005 dollars by the U.S. GDP deflator.

Table 8. Variables definition in the *de alio* and *de novo* studies

Key variables	Definition
y	Firm's sales growth rate, y_{it}= $\ln S_t$-$\ln S_{t-1}$, (S_t: sales of the applicable year, S_{t-1}: sales of the previous year)
de_novo	Dummy variable for d*e novo*(de novo=1)
subsector	Dummy variable for the equipment industry (Equipment subsector=1)
de_novo x ln_sales	Interaction term of *de novo* and ln (sales)
age	Age of a firm
profit_ratio	Ratio of profits earned to sales (profit/sales)
ln(sales)	Logarithm of firm *i*'s sales in year *t*
rnd_intensity (t-1)	Company *i*'s R&D intensity(= R&D/sales) in year *t*–1

The regression model is expressed as follows.

$$y_{it} = \alpha_{it} + \beta_1(de\_novo)_i + \beta_2(subsector)_i + \beta_3(de\ novo \times \ln(sales))_{it}$$
$$+ \beta_4(age)_{it} + \beta_5(profit\_ratio)_{it} + \beta_6 \ln(sales)_{it} + \beta_7(R\&D\ int)_{it-1} + e_{it} \quad \text{Eq.(13)}$$

Eq. (13) can be regressed by panel models such as fixed and random effect models. α_i could be regarded as a random variable that is not uncorrelated with any covariates if we can guarantee a random selection process from the population. And then, the random effect model is more appropriate than the fixed effect model. On the other hand, the fixed effect model considers α_i as a parameter rather than a random variable; thus, β_1 and β_2 cannot be estimated.

Therefore, the random effect model is usually used to examine the effect of firm-specific variables (Clarke et al., 2010). This paper also aims to identify whether *de alio* or *de novo* firms achieve faster sales growth when entering the market and how long this effect lasts in the new and renewable energy industries. In this type of research where a dummy variable is a main independent variable, this model is useful as it identifies the coefficients of dummy variables that are omitted in the analysis with the fixed effect model and verifies their significance. Thus, the random effect model was adopted.

4.4 Empirical analysis

4.4.1 Results of descriptive statistical analysis

Because the entry month of each firm can be different, even within the same cohort, sales in the entry year cannot be considered annual sales. Furthermore, there are typically many missing values in the entrance year. Alternatively, we assume the year after entrance as the first year.

As shown in Table 9, after the 1990s, the alternative sector of the Thomson Reuters Datastream included 292 firms, of which 154 firms were *de alio* and 138 were *de novo*. *De alio* firms make up a larger proportion than *de novo* firms in the new and renewable energy industries. When subdividing new and renewable energy industries into equipment and fuel subsectors, the results show that while the number of *de alio* and *de novo* firms was almost the same in the equipment subsector, the entry proportion of *de alio* firms is higher in the fuel subsector. As mentioned in section 4.2, initial capital investment and manufacturing process are considered more important in the fuel subsector than the equipment subsector, and *de alio* firms enter the fuel subsector more frequently than *de novo* firms.

The actual panel data analysis was performed with the 292 firms that entered the industry from 1990 to 2010. Figure 3 shows that the number of entrants began to increase in the late 1990s. Subsequently, there was a gradual decline after the peak in 2006. Table 8 provides descriptive statistics from 1991 to 2010, which are graphically presented in

Figure 4. As Table 10 and Figure 4 show, the average sales and average total assets gradually fell in the late 1990s and changed their courses to a subsequent rise after 2000. In consideration of the increase in the number of entering industries after 2000, it can be concluded that the new and renewable energy industries were in the growing stage in 2000.

Table 9. The number of *de alio* and *de novo* firms in the new and renewable energy industry

	Fuel subsector	Equipment subsector	Total
De alio	62 (21.2)	92 (31.5)	154 (52.7)
De novo	44 (15.1)	94 (32.2)	138 (47.3)
Total	106 (36.3)	186 (63.7)	292 (100)

Numbers in parentheses are frequency cell percentage.

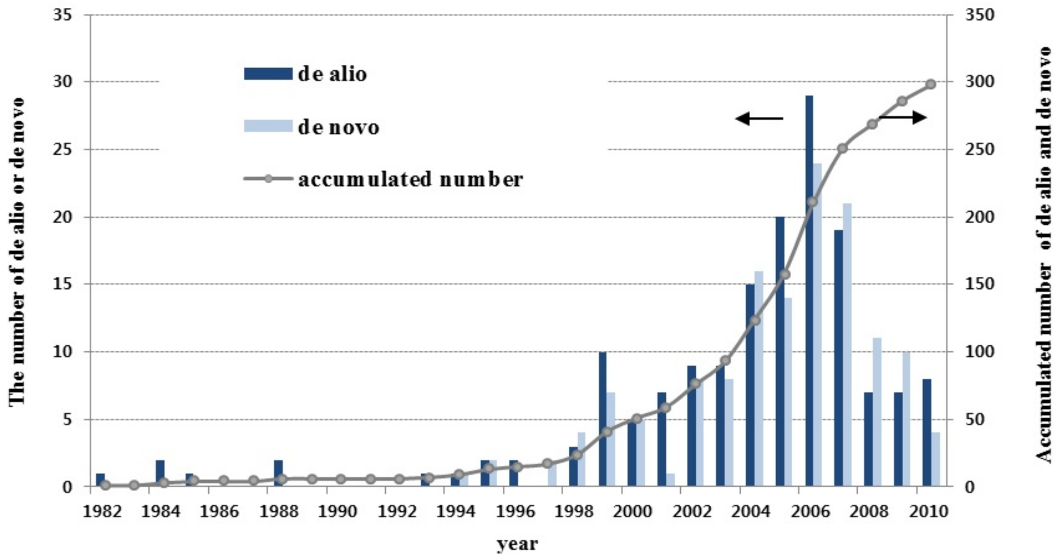

Figure 3. Annual number of entry firms in the new and renewable industry

Table 10. Observations and median of key variables by year in the new and renewable energy industry

Year	Statics	Sales growth	Sales ($millions)	CAPEX ($millions)	R&D intensity
1991	no. of obs.	6	6	5	6
	median	0.06	183.42	4.92	0.02
1992	no. of obs.	6	6	5	6
	median	0.14	213.81	7.95	0.02
1993	no. of obs.	5	6	5	6
	median	-0.15	124.52	3.97	0.00
1994	no. of obs.	6	8	7	8
	median	0.08	90.08	3.99	0.00
1995	no. of obs.	8	11	10	11
	median	0.18	48.97	3.01	0.00
1996	no. of obs.	12	13	12	13
	median	0.11	74.25	3.43	0.00
1997	no. of obs.	14	16	13	15
	median	-0.04	39.69	2.25	0.00
1998	no. of obs.	16	23	22	22
	median	-0.11	15.70	1.20	0.00
1999	no. of obs.	22	38	35	38
	median	0.07	7.88	0.38	0.00
2000	no. of obs.	40	50	49	47
	median	0.06	5.63	0.17	0.00
2001	no. of obs.	48	56	55	54
	median	0.00	6.86	0.64	0.00
2002	no. of obs.	52	68	68	67
	median	0.06	4.59	0.34	0.00
2003	no. of obs.	71	86	85	83
	median	0.10	4.41	0.47	0.00
2004	no. of obs.	85	113	109	103
	median	0.01	3.69	0.21	0.00
2005	no. of obs.	108	136	135	125
	median	0.09	6.28	0.30	0.00
2006	no. of obs.	141	186	182	174
	median	0.21	7.29	0.31	0.00
2007	no. of obs.	183	219	217	204
	median	0.31	8.19	0.78	0.00
2008	no. of obs.	229	244	244	228
	median	0.30	10.18	1.36	0.00
2009	no. of obs.	231	252	251	237
	median	0.24	12.71	2.43	0.00
2010	no. of obs.	257	274	273	259
	median	-0.02	11.77	1.17	0.00
Total	no. of obs.	1540	1811	1782	1706
	median	0.10	8.58	0.79	0.00

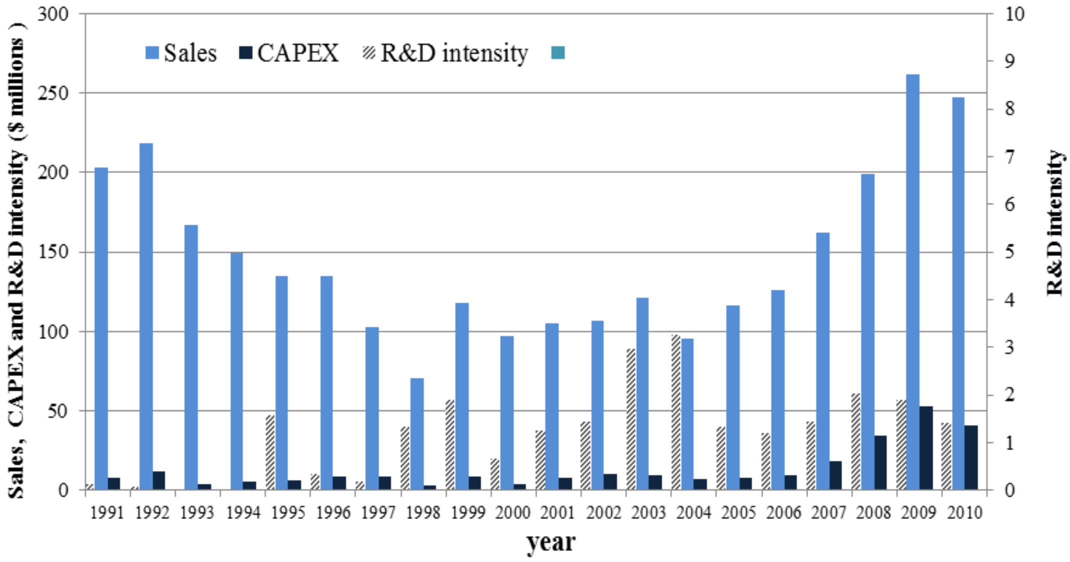

Figure 4. Annual averages of sales, CAPEX, and R&D intensity of *de alio* and *de novo* firms

Table 11 shows the averages of sales, CAPEX, and R&D intensity for *de alio* and *de novo* firms. The values for the equipment subsector were higher than those for the fuel subsector. As equipment subsector firms work primarily in the field of manufacturing end products for solar power, wind power, and fuel cells, it could be concluded that investments in new facilities and R&D are necessary.

The results show that *de alio* firms have higher sales for both subsectors (equipment, fuel). While *de alio* firms have higher CAPEX in the equipment subsector, *de novo* firms have these advantages in the fuel subsector. This result implies that the *de alio* firms that receive abundant R&Cs from their parent company maintain high sales. In the fuel subsector, which requires initial investment, the results seem to show that more investment is put into *de novo* firms. On the other hand, in the case of R&D intensity, *de novo* firms appeared to show consistently higher R&D intensity regardless of the subsectors; thus, it can be deduced that the technological innovations of *de novo* firms are actively progressing.

Table 11. The mean and standard deviations of sales, CAPEX, and R&D intensity

Variables	*de alio*		*de novo*		Total	
	Fuel	Equipment	Fuel	Equipment	Fuel	Equipment
Sales	45.8	330.3	31.7	111.9	39.9	230.7
$millions	(115.4)	(1209.2)	(137.4)	(359.7)	(125.1)	(930.5)
CAPEX	8.0	38.4	13.3	22.1	10.2	31.0
$millions	(21.4)	(153.6)	(44.8)	(78.8)	(33.1)	(125.1)
R&D	0.6	1.0	3.3	2.8	1.7	1.8
intensity	(4.1)	(7.6)	(14.3)	(11.7)	(9.6)	(9.6)

Numbers in parentheses are standard deviation.

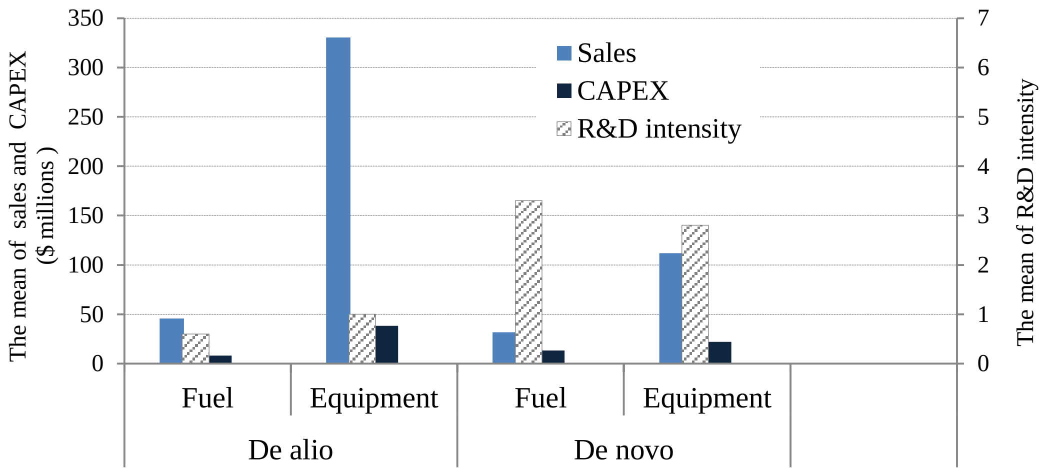

Figure 5. The mean of sales, CAPEX and R&D intensity of *de alio* and *de novo* firms

As shown above, the new and renewable energy industry entered its growing stage in the 2000s, and the equipment subsector, which primarily involves manufacturing and equipment, shows relatively higher average sales, CAPEX, and R&D intensity than the fuel subsector. Thus, these results imply that the equipment subsector leads the new and renewable energy industry. Additionally, *de novo* is a major entry mode in the manufacturing and equipment industries, which have a high appropriability of technology.

4.4.2 **Results of regression analysis**

Table 12 shows that the number of observed targets, average value, standard deviation and the correlation matrix for main variables and main dummy variables. Except for the correlation between de_novo and the interaction variables, it was verified that the crossed correlation among variables is not very high.

Table 13 shows the effects of the *de alio* and *de novo* modes on sales growth rates after market entry.

In our results, the age variable shows a negative sign with firms below the sixth year after entrance. The logarithm variable of sales (ln_sales), a proxy for firm size, has a statistically significant negative value with firms younger than three years but a statistically significant positive value with four-to-six-year-old firms. It is generally acknowledged that firm age and size have an inverse relationship with firm growth. Other studies maintain that the initial negative relationship turns positive after a time interval (Arne and Mulu, 2007). We can explain the early inverse relationship by observing that small or young entrants face several limitations when starting a business in the new and renewable energy industry. A high level of uncertainty arising from oil price fluctuations surrounds this early stage industry. However, neither age nor size has a significant relationship with firm growth for firms over the seventh year after entrance. This indicates that, in the new and renewable energy industry (unlike in existing industries), age and size play only a small role in firm growth. On the other hand, the profit ratio has statistically insignificant values for firms younger than three years but statistically significant positive values for firms older than four years. That R&D intensity boosts firm growth is consistent with the literature (Coad, 2009).

Model 1 show that the de_novo dummy variable is statistically significant and has a negative coefficient until the third year after market entrance. Thus, the sales growth of *de alio* firms is higher than that of *de novo* firms because *de alio* firms enter the market with the full resources, capital, and human resources support of the parent company (Mitchell, 1994); thus, such firms have no problem entering a new industry. In addition, the initial growth appears to be higher because of the brand value prior to entry, which gives them an immediate large market share (Klepper and Simons, 2000). However, Model 2 and Model 3 show that de_novo dummy variable is statistically insignificant, which implies that this *de alio* effect disappears after the fourth year of market entrance, suggesting that the effect of the R&Cs advantageously applied to *de alio* firms decreased over time because of the firms' rigidity and inertia. Models 1 to 3 also show that the interaction variable of the *de novo* mode and sales has a statistically significant and positive coefficient until the third year after market entrance, implying that *de novo* firms achieve higher growth rates as their sales increase. These results lead us to expect that large *de novo* firms are likely to catch up to *de alio* firms over time. Thus, as time passes, *de novo* firms accumulate more resources and competencies, which may erase any distinction between *de alio* and *de novo* firms.

Models 2 to 3 show that the growth rates in the equipment and fuel subsectors showed significant results after the fourth year of market entrance. This means that the industrial characteristics in the new and renewable energy industry are likely to have an important influence on firms' growth patterns. Meanwhile, R&D intensity has a positive effect on sales growth, indicating that R&D investment affects firm growth.

Innovation in products, process, and techniques through R&D investment help firms secure competitive advantages and eventually achieve firm growth. This is why researchers frequently use an R&D variable in studies on firm growth. Widely used R&D variables include R&D stock, R&D expenditure, and R&D intensity. R&D capital stock is a good measure of growth but is limited to short-time series analysis. Therefore, we use R&D intensity as a proxy for R&D capital stock in the firm growth equation. Since the total R&D expenditures reveal a very strong correlation with sales, we use R&D intensity instead of total R&D expenditures. Many studies have investigated the influences of R&D intensity on firm growth. Most argue that the initial R&D intensity shows a positive correlation with employment growth (Hall, 1987), while other researchers maintain that R&D activities have nothing to do with firm growth. Brouwer et al. (1993) observe that

R&D intensity has an inverse relationship with employment growth (Brouwer et al., 1993). Despite the contrasting views on the relationship between R&D intensity and firm growth, it is no exaggeration to say that a great many researchers have used R&D intensity as an estimate of innovation expenditures and innovation outputs to measure firms' innovation activities.

As indicated in Table 11 and Figure 5, *de novo* firms have higher R&D intensity than *de alio* firms, likely an indication that *de novo* firms more actively engage in innovation activities. According to the regression analysis shown in Table 13, *de novo* firms show lower growth rates than *de alio* firms in the early years, until three years after entry, because the former lack inherited R&Cs (see Model 1). This phenomenon becomes insignificant, as demonstrated in Model 2 and Model 3. The attributes of *de alio* and *de novo* firms affect short-term performance, but the influences fade over the long term. Recent studies have found that the survival rates of *de novo* and *de alio* firms change over time and that firms' *de alio* and *de novo* features disappear over the long term (Chen et al., 2012). Out results show that the gap between the two closes more quickly than the current literature suggests.

Regarding the interaction variable of de_novo and ln(sales) (de_novo x ln_sales), large-scale *de novo* firms show high growth rates in the early years; however, the advantages arising from their large size weaken after four years. On the other hand, the coefficients of d_subsector indicate that the subsector influences firms' growth rates even after the early years, while firms in the fuel subsector show higher growth rates than their counterparts in the equipment subsector. In terms of sales and R&D investments, the equipment subsector shows higher average growth rates than the fuel subsector does. On the contrary, equipment subsector firms, such as wind power and solar energy producers, have relatively vulnerable factors for firm growth. They should fight a price war against the manufacturers of fossil fuels, whose prices are related to fluctuating oil prices. Amid the uncertainty of fluctuating oil prices, they still have a long way to go before they establish a stable production capacity and commercialize the technology, as well as breaking the high technological barrier (Johnstone et al., 2010; Schilling and Esmundo, 2009).

Our results indicate that the effect of a firm's innate features on the sales growth rate weakens as time passes. Similar results have been found in the literature (Khessina and Carroll, 2008), which reveals that the exit rate of *de novo* firms slows as time passes and eventually tends to converge with the survival rate of *de alio* firms. However, our study can be differentiated from Khessina and Carroll (2008), as it has not only determined whether the difference between *de alio* and *de novo* exists but also identified its decreasing pattern concretely.

Table 12. Descriptive statistics for variables of *de alio* and *de novo* firm studies

		Obs	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.
1.	y	1540	0.547	2.167	1.000							
2.	de_novo	1827	0.441	0.497	0.016	1.000						
3.	d_subsector	1827	0.655	0.475	-0.036	0.027	1.000					
4.	de_novo x ln_sales	1667	3.266	4.673	0.050	0.940	0.052	1.000				
5.	age	1827	4.290	4.329	-0.201	-0.167	0.031	-0.142	1.000			
6.	ln_sales	1347	8.790	3.670	-0.405	-0.114	0.207	0.071	0.283	1.000		
7.	rnd_int (t-1)	1447	1.742	9.392	0.174	0.070	0.039	-0.008	-0.001	-0.284	1.000	
8.	profit/sales	1482	-7.963	38.017	0.133	-0.063	0.078	0.062	0.022	0.317	-0.224	1.000

Table 13. Regression results of *de alio* and *de novo* studies

Dependent Variables : sales growth	Model 1 ($\leq 3^{rd}$ year) coef. (std. err.)	Model 2 (4^{th} ~6^{th} year) coef. (std. err.)	Model 3 ($\geq 7^{th}$ year) coef. (std. err.)
de_novo (de novo=1)	-2.206**	0.983	0.106
	(0.914)	(0.916)	(1.152)
d_subsector (equipment=1)	-0.478	-1.062***	-0.722**
	(0.339)	(0.338)	(0.313)
de_novo X ln_sales	0.237***	-0.117	-0.009
	(0.086)	(0.084)	(0.099)
age	-0.647***	-0.269***	-0.002
	(0.178)	(0.082)	(0.019)
profit / sales	0.006	0.008**	0.008*
	(0.006)	(0.003)	(0.004)
ln_sales	-0.137**	0.134**	0.067
	(0.062)	(0.067)	(0.065)
rnd_intensity (t-1)	0.061***	0.050***	0.047***
	(0.018)	(0.019)	(0.008)
year dummy		included	
constant	3.523***	1.214	-0.089
	(0.853)	(0.780)	(0.888)
R2 overall	0.14	0.09	0.08
Observations	363	484	414
Number of firms	209	207	101

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

We also conducted a quantile regression analysis[6] to examine the relationship between the entry modes and growth rates. We divided the entrants into nine quantiles according to growth rates, a division that clearly shows how the effects of the independent variables of entry modes on growth rates differ according to the entrants' age.

As shown in Figure 6, the coefficient for *de novo* firms under three shows a sharper decline in the higher growth groups. The *de novo* firms in the higher growth groups exhibit lower growth rates, another indication that the effects of *de alio* firms become stronger in the higher growth groups. We detected a similar pattern for four-to-six-year-old *de novo* and those over the seventh year of entrance. The effect of *de novo* firms on growth rates shows consistently low negative values up to the 7th quantile, and the value turns positive after the 8th quantile.

We interpret these results as follows.

For firms under the third year of entrance, the *de novo* effect on growth rates varies depending on the group.

For four-to-six-year-old firms and firms over seventh year of entrance, the effect disappears but drastically turns positive only in groups higher than the 8th quantile.

As indicated in Table 13, the *de novo* effect wears off over time. In the high-growth

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[6] The quantile regression model can be written as (Koenker and Bassett, 1978):
$y_i = x_i'\beta_\theta + u_{\theta i}$, $\mathrm{Q}_\theta(y_i \mid x_i) = x_i'\beta_\theta$ where y_i is the dependent variable, x_i the vector of independent variables. β_θ is the vector of the parameters to be estimated for a given value of the quantiles θ. $\mathrm{Q}_\theta(y_i \mid x_i)$ is the θ th quantile of y_i given x_i.

groups, the growth rate gaps between *de alio* and *de novo* firms narrow more significantly over time than in the low-growth groups.

For both *de alio* and *de novo* firms, the effect of the firm's innate features on sales and growth rate weakens over time. Similar results have been found in the literature (Khessina and Carroll, 2008), revealing that the exit rate of *de novo* firms slows as time passes and eventually tends to converge with the survival rate of *de alio* firms. However, this study can be differentiated from Khessina and Carroll (2008) because we have not only examined whether the difference between *de alio* and *de novo* exists but also identified its decreasing pattern.

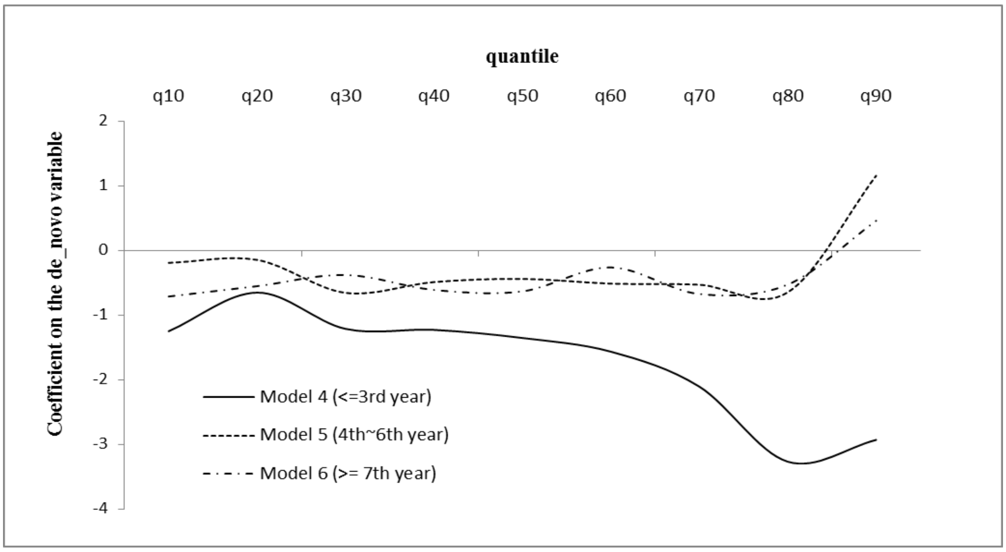

Figure 6. Quantile regression results on sales growth of *de alio* and *de novo* firms[7]

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[7] Since the coefficients are not statistically significant, the results table was not included in in the paper. Instead, interpretations of the results table are provided in the appendix of this thesis.

4.5 Summary

Several important conclusions can be drawn from Chapter Four.

First, companies' sales averages gradually declined in the late 1990s and then drastically increased after 2000 in the new and renewable energy industry. Given the increase in the number of entrants after 2000, it can be concluded that the new and renewable energy industry entered a growth stage at that time. Sales in the equipment subsector were found to be higher than those in the fuel subsector; the equipment subsector clearly deals with the manufacturing of end products, including important products used in solar energy, wind energy, and fuel cells.

Second, *de alio* firms have higher average sales than *de novo* firms, while *de novo* firms tend to have a higher R&D intensity than *de alio* firms, which may indicate that *de alio* firms start with more resources and higher competence levels while *de novo* companies start with a higher potential for technology innovation.

Third, although *de alio* firms with ample resources show higher growth rates, this gradually decreases over time. Moreover, four years after market entrance, the difference between the sales and growth rates of *de alio* and *de novo* firms decreases because the systematic characteristics of *de alio* and *de novo* firms fade and eventually disappear over time.

Fourth, *de novo* firms achieve higher growth rates as their sales increase, leading us to expect that large *de novo* firms are likely to catch up to *de alio* firms over time.

As firms tend to grow over time, the third and fourth conclusions imply that the difference between *de alio* and *de novo* firms in terms of sales becomes (ceteris paribus) diluted over time.

This study has established that the characteristics of *de novo* and *de alio* firms in the automobile and electronic sectors as well as other growing sectors that have been analyzed in previous studies can be expanded to include the new and renewable energy sector. Therefore, *de alio* firms that have received R&Cs from their parent companies have a market competition advantage against *de novo* firms that undertake the challenge of new environments through technology innovation.

Studies in this field have been limited to examining firms' long-term survival rates. By contrast, this study has analyzed the growth rates of new firms, which may be a direct and immediate cause of firms' survival. This investigation explored short-term firm growth in growing industries using the *de alio* and *de novo* dichotomy, finding that the effects of *de alio* and *de novo* firms fade over time and that these innate conditions begin to conflict with the R&Cs firms acquire as they grow. Thus, this study indicates that, although R&Cs received from parent companies prove to be advantageous in the early stages of a company, they eventually expire, and new R&Cs must be secured.

This study has certain limitations. It does not examine the causes of the changes in the *de alio* and *de novo* effects. Future research should conduct an in-depth analysis on why the effects of *de alio* firms' R&Cs weaken over time. In addition, studying industries other than the new and renewable energy industry will allow comparative analyses of the general growth patterns of *de alio* and *de novo* firms from the sectoral regime perspective.

Chapter 5. The Effects of Evolution of Resources and Capabilities on Firm Growth

5.1 Introduction

New firms enter the market with different motives and initial statuses in terms of their internal/external conditions, yet the goals remain the same: stable settlement, economic growth, and sustainable survival in the market. However, not all firms can be successful in this competitive society, and even currently successful firms cannot predict their own futures in an uncertain market environment. Extensive evidence demonstrates that few new firms achieve success; for example, according to Santarelli and Vivarelli (2007), more than half of the newly established firms disappear within five years of establishment.

Many theories and verified results have been presented concerning the environments that firms are able to grow in and the conditions that enable firms to survive. However, in this dynamic situation, where industrial structures, market environments, characteristics of firms, and related factors are continuously changing, management theories and realities for firms continue to change accordingly.

Organizational ecology theory, discussed in Chapter Three, explains the survival and growth of firms by stating that the environment selects firms. Despite firms' strategic responses and adaptive efforts, the environment's influence is difficult to avoid. Structural inertia within firms prevents them from responding quickly to the rapidly changing environment; thus, firms customized to the existing or previous environment eventually disappear, and firms with strategies and structures fit for the new environment start to appear (Hannan and Carroll, 1992; Hannan and Freeman, 1984).

Resource-based theory explains that the resources a firm holds determine its strategies and competitiveness. The firm's capabilities, on the other hand, provide the fundamental drivers for growth and survival. The theory argues that as firms secure R&Cs that are difficult to gain and copy, sustainable competitive advantages are created, contributing to the firms' growth and survival (Amit and Schoemaker, 1993; Barney, 1991; Hamel and Prahalad, 1990; Wernerfelt, 1984).

The evolutionary theory refutes the initial organizational ecology theory. In contrast to the existing argument of firms being incapable of adapting to environmental changes, it explains that in the process of changing and adapting themselves, firms expand their knowledge and capacities relevant to the environment they operate in. The differences in firms' abilities to acquire new routines and their learning capabilities are the main factors that affect their evolution. Therefore, evolutionary theory maintains that firms that are able to progress through the exploitation of the best alternatives from their existing achievements and the exploration for new solutions in an uncertain future can be guaranteed to grow and survive (March, 1991; Nelson and Winter, 1982).

It is true that it is difficult to generalize the causes for the success or survival of newly established firms due to numerous complex factors responsible for growth. New firms are too inexperienced to establish internal R&Cs and do not have enough external recognition to induce external cooperation, and thus have a “liability of newness.” Due to these reasons, organizational ecology argues that new firms tend to disappear and do not have the structural inertia to adapt to the environment (Freeman et al., 1983). There have been many studies on the characteristics and effects of structural inertia; however, few detail when the inertia starts to occur and what causes the change. The weakness of organizational ecology theory is that since it pays attention to the replaced firms through differential selection by the environment and considers the yield rate and extinction rate of demographic vital rates as major dependent variables. Therefore, it requires long-term observation and is difficult to use as a strategic management theory for predicting and valuing the mid- and long-term growth of firms.

The theory of firm evolution deals with the areas that cannot be explained clearly by the earlier firm growth theories. In the case of a new firm, which has insufficient initial experience, its path dependent knowledge base (Nelson and Winter, 1982) is initiated. Therefore, it looks at not only the (natural) R&Cs inherited prior to the firm’s entrance in the market, but also at how nurtured R&Cs are acquired through experiences and efforts as well as how these newly acquired R&Cs impact the firm’s growth. However, empirical researches on how these R&Cs influence the growth rate of firms and how long these effects last are few in number, and no clear conclusions have been drawn.

This point is significant from a management strategy perspective; nevertheless, few in-depth researches have been performed on the dynamic evolutionary processes of acquired R&Cs.

The eventual goal of management strategies is to locate the causes of differences in management performance or growth rates among firms. So far, their fundamental causes have been considered to be the internal R&Cs that the firms already have. It is not too difficult to understand that R&Cs create differences in firms' future performances; however, it is difficult to verify this with empirical research, which requires their direct measurement. Furthermore, with regards to R&Cs, there have been mixed results from empirical studies as there is ambiguity as to whether they were present in the original environments of the new firms or have evolved and accumulated during business activities. Very few empirical results exist concerning which resources, both inherited and nurtured, are more effective to the future growth of a firm.

In an effort to understand the creation and evolution of R&Cs dynamically, the present research compares new firms' pre-entry experiences immediately before establishment and the intensities of the experiences after the establishment as well as conducting an empirical analysis on their impact on the long-term growth of firms. The purpose is to understand the initial creation process of R&Cs and their effects on the future growth dynamically, which has not been clear in various other empirical researches.

In addition, the present research assumes that the initial structural inertia of a new firm is due to R&Cs from the pre-entry experience and nurtured resources and capacities acquired from the post-entry effort. Depending on the types of post-entry efforts and the degree of efforts, the state and sustainability of effects is determined. Depending on the initial structural inertia, strategic decisions on the size of business and the amount of investment in production facilities or R&D might be different.

In this chapter, Section 5.1 reviews existing research on the respective impacts of nature and nurture R&Cs on the growth of firms. Section 5.3 explains the results of the empirical analysis based on the research design and the models suggested in Section 5.2, Finally, a summary of the findings is presented in Section 5.4.

5.2 Previous studies

5.2.1 Firm growth

In discussing the growth of a sizable firm that already operates in business, the frequently used management strategic viewpoint is R&Cs. The abundant resources that a firm owns and its differentiated core capabilities serve as leverage to lower the market risks and exploit new opportunities. Capital, technologies, organizational structure, experiential knowledge and other R&Cs continue to be accumulated and transferred and are the sources for firms to grow continuously (Teece and Pisano, 1994).

R&Cs are not always helpful to the growth of a firm. The firm adequately equipped with these can possibly implement progressive innovation through the organizational routine, but firms lacking in organizational flexibility due to the inertia do not adapt to the rapidly changing environment and thus cannot promptly respond with progressive and innovative activities (Christensen *et al.*, 2004).

New firms consist of diversified firms entering the market with sizable R&Cs inherited from their parent firms, spin-off firms (*de alio*), and start-up firms (*de novo*) entering the market without fundamental R&Cs but solely with dynamic innovative capabilities.

Core capability is a frequently addressed topic when discussing the growth of a new firm or a firm in the technology-intensive industry. New firms entering the market do not have inherited R&Cs and thus are not influenced by existing methods. In addition, in new industries, since new firms do not have information on existing firms, they tend to go forward solely with trust in their core technologies. Also, their small size and flexibility enables them to promptly respond to the changes in the environment (Hannan and Freeman, 1984; Haveman, 1992). New firms tend to be ahead of the prevalent technology in the beginning, but since their accumulated R&Cs are insufficient and their position in the industry, brand value and experience are insubstantial, they might fall to failure (Bruderl *et al.*, 1992).

Therefore, in researching the growth pattern of new firms, R&Cs are important bases for making decisions.

5.2.2 **Previous studies on pre-entry experience**

Several difficulties are found in analyzing the impacts of R&Cs on the firm growth rate. First, it is difficult to detect when R&Cs start to be generated and the impact of the acquired R&Cs tends to change over time. In addition, R&Cs generated from business activities are a mixture of several factors. Thus, it is difficult to separate and analyze the effects of particular R&Cs. Various researches have been conducted on *de alio* and *de novo* firms by excluding the R&Cs gained during the business activities and focusing on the R&Cs generated based solely on their pre-entry experience (Carroll et al., 1996; Khessina and Carroll, 2008).

De alio and *de novo* firms enter the market at the same time. However, depending on their pre-entry experiences and the types of these experiences, they start with different organizational types and different patterns of innovative activities (Khessina and Carroll, 2008) or marketability (Carroll *et al.*, 1996) are revealed. In the case of a *de alio* firm, which has pre-entry experience, since it receives sufficient support in terms of resources, capital and manpower from the existing firm (Mitchell, 1994), regardless of its success, it can proceed with business (Levinthal, 1991). The resources, capabilities and brand value received from the previous firm help raise market share (Klepper and Simons, 2000) and serve as an advantage for the *de alio* firm's long survival in the market (De Figueiredo and Kyle, 2006). The stable organization system and manufacturing routine increase the credibility of products leading to higher possibility of success (Hannan and Freeman, 1984). In addition, experiences in the market enable them to promote their products more effectively (Nerkar and Roberts, 2004) and the new products relevant to the reputation of their parent-firms have favorable position in terms of advertisement when released (Podolny, 1994; Swanson, 2002).

On the other hand, a *de novo* firm without the pre-entry experience, does not have

R&Cs compared to a *de alio* firm, but various empirical researches prove that it has the advantages of flexibility and prompt responses to changes in the environment (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firm tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008) and innovative companies survive longer in the market (Stavins, 1995).

Since a *de novo* firm is naturally free from the technological trace that a parent firm holds, it has an inborn tendency to try innovative technologies. It makes an effort to acquire the best technologies and tends to have a business structure fit for competition.

A common phenomenon found in *de alio* and *de novo* firms is that organizational characteristics are changing with time. For *de alio* firms, R&Cs favorable for survival rate generate side effects past the initial period, such as problems of organizational rigidity and inertia. For *de novo* firms, the flexibility to change with the environment helps gain R&Cs as time goes by and accordingly, the exit speed of products becomes longer and eventually it catches up with the survival rates of *de alio* products (Khessina and Carroll, 2008). Surely, after a certain period of time, *de novo* also finds itself in difficulties with inertia, the same as *de alio* (Carroll *et al.*, 1996).

The concepts of *de alio* and *de novo* explain the effects of the pre-entry experience adequately. The shortcomings are that these concepts have been used to analyze survival or extinction and not many empirical analyses have been conducted on the effects of these concepts on the long-term performance of a firm. In addition, it is rare to locate researches that examine how the characteristics of *de alio* and *de novo* firms change when the new nurture experience is added after entrance to the market to the nature R&Cs dividing *de alio* and *de novo* firms.

5.2.3 **Previous studies on post-entry efforts**

The impact of business activities and experiences on the performance of a firm has been researched. However, this research did not examine post-entry effort specifically, but multiple aspects of an entire range of business activities.

A firm's management activities lead to the firm's learning by doing (Arrow, 1962), and its strategies, organizational operation, investment in R&D, acquisition of external knowledge, alliance, M&A activities, and related factors have direct impacts on its performance. However, most researches are limited to the analysis of their short-term impacts on business activities and performance, and are not applicable for the analysis of long-term performances. This is especially true of researches on the impact of the firm's initial experience on long-term business performance, which have not gained much attention from the academia. Some limited researches on new firms or entrepreneurship dealt with analyses of the initial activities of firms (Aldrich, 1999; Costello, 1996; Cyert and March, 1992; Deakins and Freel, 1998; Hambrick and Schecter, 1983; Hugo and Garnsey, 2005; Kim et al., 2009).

The researches dealing with companies' initial business activities and experiences analyze how initial experiences have impacted their survival and short-term performance. Theoretical and positive analyses are available on the impact of experiences, such as operating experience (Kim et al., 2009), problem solving experience (Hugo and Garnsey, 2005), success experience (Aldrich, 1999; Cyert and March, 1992) and recovery experience (Hambrick and Schecter, 1983). The Deakins and Freel's research (1998) explains that the initial activities of a company affect its future organizational learning and the formation of its routine. In the experiences and activities that a business organization undergoes, the company learns via trial-and-error and this learning is internalized as the company's own problem-solving method, response to the changes in the market environment and culture, and becomes a routine (Deakins and Freel, 1998).

The routine of an organization refers to its generalized organizational activities and is represented as the organizational culture. Routine is based on the research of evolutionary economics (Levitt and March, 1988; Nelson and Winter, 1982). The routine internalized in a firm enables the effective utilization of the limited capacity (Louis and Sutton, 1991; Simon and Barnard, 1976; Winter, 1985), and is used as a strategic tool to respond to the uncertain environment (March and Simon, 1958; Weiss and Ilgen, 1985). The routine provides safety to the organizational operation, affects the operation of a company (Hodgson, 1997) and wide range of activities such as adjustment and cooperation among stakeholders inside the organization (March and Olsen, 1989; Nelson and Winter, 1982), and makes an impact on the performance of the firm.

The initial experiences and activities of a firm become its routine through the learning process, and in the long term (Deakins and Freel, 1998), these have an impact on the firm's operation, culture and performance methods (Levitt and March, 1988).

Table 14. Details of pre-entry experience and post-entry effort

	Previous studies	Characteristics of the operation definition
Pre-entry experience	· The research on *de alio* and *de novo* firms has focused on the identifying of the effects of the pre-entry experience. *De alio* refers to a firm with pre-entry experience, *de novo* to one without.	· *De alio**) – Exposed to less danger – Obtain a higher market share – Survive longer. – More effectively advertise their products · *De novo* – Flexible organization and prompt response to the change of environment – Innovative products
Post-entry efforts	· The firm learns through various experiences – Operating experience – Problem solving experience – Success experience – Recovering experience	· Growth rate is higher than the average growth rate of firms in the same industry, which considers that the strength of post-entry effort – Capital investment activities – R&D investment in manufacturing facilities – The individual worker′s experience due to the expansion of the labor force

* 1 for a firm affiliated with a corporate group and 0 for others in this chapter

5.3 Research design and analysis model

5.3.1 Research questions

The research examines the effects of R&Cs on the sales growth rate of firms. First, the research looks into the effects of the inherited R&Cs on the growth rate of sales. To understand this, the concepts of *de alio* and *de novo* are used. Since *de alio* firms have previous experiences, they are known to have more R&Cs while *de novo* firms have fewer inherited R&Cs while they have more flexibility and innovativeness.

The development of a *de novo* firm was difficult to interpret from the resource-based perspective. While it is rational to explain the high survival rate of a *de alio* firms as being due to relatively superior R&Cs, from an organization ecology perspective, it is inadequate to explain the successes of a *de novo* firm with its naturally insufficient R&Cs. Therefore, the current research intends to confirm that even if a *de novo* firm with insufficient natural R&Cs achieves post-entry efforts through flexible organization and innovative operation, the nurtured R&Cs that it is expected to create and the post-entry effort are as important to the firm's growth as pre-entry experience. Pre-entry knowledge and learning affect the growth and survival of new firms as much as pre-entry experience does (Dencker et al., 2009).

The question here is whether the effects of the pre-entry experience are direct or indirect and how long the effects last. However, it is difficult to reach a clear conclusion. Until recently, there have been mixed results on the effects of pre-entry experience in determining the characteristics of *de alio* and *de novo* firms. Thus, the following hypothesis is proposed:

Hypothesis 1: Pre-entry experience does not influence the long-term growth rate but only the short-term growth rate.

First, the research intends to confirm that the R&Cs inherited from the pre-entry experience influence the short-term growth rate of firms but not the long-term growth rate through Hypothesis 1. *De alio* and *de novo* firms are classified by their affiliation or lack thereof, respectively, to a corporate group, and this affiliation is used as a proxy variable in the present analysis.

Second, the research examines how nurtured R&Cs that the new firms gain from various efforts and experiences right after establishment influence firms' sales growth rates. To determine this, the activities and experiences of firms are measured for a certain period of time (4 years) after their establishment compared to other older firms in the same industry.

New firms will estimate their R&Cs with or without their pre-entry experience (Helfat and Lieberman, 2002), judge whether they fit into the new market environment or not, and eventually enter the market. Therefore, pre-entry experience can be the decisive factor affecting post-entry effort. Thus, classifying the effects of post-entry efforts and those of pre-entry experiences can be considered an important process. That is, post-entry effort should focus on the cultivating of R&Cs by a firm through the process of learning by doing over a certain period of time immediately following its establishment. It is important to study a firm's post-entry activities after it enters a new industry in order to gain a more complete understanding of its short and long-term performance.

Since the publication of March's (1991) pioneering article, the terms "exploration" and "exploitation" have emerged as the twin concepts underpinning organizational adaptation research (Gupta et al., 2006). Exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a "failure trap". In contrast, exploitation often leads to early success, which in turn reinforces further exploitation along the same trajectory, thereby creating a "success trap" (Gupta et al., 2006). However, March (1991) appeared very clear in his theorization that both exploration and exploitation are essential for long-run adaptation.

In order to adequately explain the effects of R&Cs acquired through post-entry effort, particularly long-term performance, it might be useful to distinguish post-entry effort by the differences in the type of exploration and exploitation or by the differences in effort over the short- and long-terms.

Operation management should be improved, while capital investment activities (Thompson, 2001), R&D investment in manufacturing facilities (Sinclair et al., 2000), and the individual worker's experience (Lazonick and Brush, 1985) due to the expansion of the labor force should be limited to the early activities of the firm. Generally, different capabilities favor either short-term performance or long-term performance; depending on the firm's focus, long-term performance can differ, with the specific firm's financial results providing important strategic implications as well as support for March's exploitation/exploration theory. Therefore, the following hypotheses are proposed:

Hypothesis 2a: Post-entry effort influences both short-term and long-term growth rates

Hypothesis 2b: Among post-entry efforts, tangible assets and employee efforts influence

short-term growth, while R&D intensity efforts influence long-term growth.

For Hypothesis 2a and 2b to be confirmed requires that the R&Cs of the firms, nurtured through post-entry efforts, influence both their long-term growth rate and their short-term growth rate and that their innovative activities are more influential on long-term performance than on short-term performance. To determine this, the research compares a new firm's average growth rates of initial investment activities and costs to those of other firms in the same industry and determines the intensity of the post-entry effort. The rate of R&D intensity refers to the applicable firm's innovative directivity; the rate of tangible assets refers to the firm's external growth directivity; and the rate of number of employees refers to the extension of products or firm size. All these are considered as post-entry efforts, and each is set as a main variable and its effect analyzed.

Hypotheses 2a and 2b entail that in the case of R&Cs nurtured from post-entry efforts, depending on the type of experience, the sales growth rate will change dynamically; different results are expected depending on whether the industry is high-tech or low-tech.

Pre-entry experience follows the passive learning model suggested by Jovanovic (1982), as explained before, since the firm is uncertain regarding the requirements of the environment or those required for entrance into the market. However, with the post-entry effort, the situation has changed. By acquiring different experiences, firms determine their own characteristics and accumulate R&Cs through competition or by predicting the future market environment; this can be said to follow the active learning model (Ericson and Pakes, 1995). In order to look at the synergy effect between active and passive learning, an additional interaction between pre-entry experience and post-entry efforts is reported. Recent research demonstrates that the durability of the effects of pre-entry experience can vary depending on the firm's post-entry effort (Thompson, 2005). Thus, it appears that a firm's pre-entry endowment of R&Cs will affect its ability to enact and adapt to subsequent change over the long term. Therefore, the following hypothesis is proposed:

Hypothesis 3: When post-entry efforts are combined with pre-entry experience, post-entry efforts may influence the long-term growth rate, based on their synergistic effect.

When the pre-entry experience and post-entry effort are closely related in terms of cause and effect, it is difficult to ascertain which one most determines the firm's growth rate. Therefore, it is necessary to confirm whether these two experiences are independent factors for growth rates and whether there are effects caused by their mutual operation. This research expected that there would be no effects from their mutual operation. To verify this, it was necessary to divide the R&Cs into nature and nurture and the sales growth rate into short-term and long-term, and to simultaneously analyze a reciprocal crossing item for each.

Therefore, the research used the triple difference (difference in difference in difference) method, which enables us to understand the result of the analysis for each as well as the quantitative significance. To determine whether a firm's growth rate is caused by pre-entry experience or post-entry effort, it is necessary to control interactional variables.

The triple difference method is very useful to understand the result of the research, as it can help determine the effects of pre-entry experience or post-entry effort on short-term or long-term results independently. This method also has the additional advantage of being able to comprehend the significance level of the coefficient of the interactional variable representing the effect of the reciprocal operation for each other on the results.

The concept models and hypotheses set in the research are as follows.

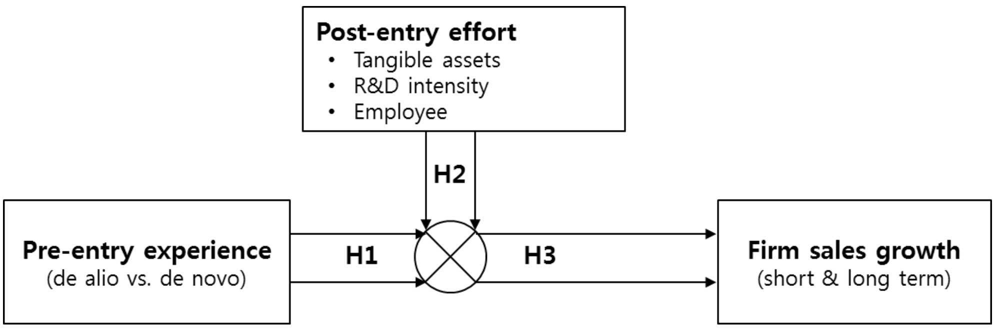

Figure 7. Conceptual hypothesis structure

The research shows that the results from H1 and H2 of Figure 7 represent that pre-entry experience and post-entry effort have independent impacts on the growth of firms, and the result (H3) from the interaction of H1 and H2 provides a crucial clue in understanding which experience, pre-entry experience or post-entry effort, has more impacts on long-term growth. Through this analysis, the research will verify whether the natural R&Cs, that new firms inherit without knowing and regardless of the market environment, have positive influences on their growth (Jovanovic, 1982), or the nurtured R&Cs gained through various activities upon entrance in the market are influential on the new firm's evolution to fit the environment (Pakes and Ericson, 1998).

5.3.2 **Data collection and analysis model**

The research used the 1985 to 2009 financial statements of NICE (National Information & Credit Evaluation lnc.) information service. These statements included information on the listed corporations in Korea, registered corporations in KOSDAQ (Korea Securities Dealers Automated Quotation) and external auditing corporations. To avoid the shock of the Asian financial crisis in 1997, which had a heavy impact on economic change, the research selected 1,080 manufacturing firms (KSIC code=10~33) that were less than 4 years old from their establishment in since 1997. According to the industry categorization standards of OECD for manufacturing, the firms were divided into high-tech industry and low-tech industry and the results of firms were compared.

As for dependent variables, the sales growth rates of firms were used in the form of natural logarithmic functions. The sales growth rates were divided into short-term (less than 4 years old) and long-term (between 7~10 years old). The financial variables of firms were adjusted based on 2005 by utilizing GDP deflator to avoid the impact of annual macro-economic changes. The main independent variables, pre-entry experience and post-entry effort, used the dummy variables to distinguish the existence of experience and the interaction variables between two experience dummy variables.

As for pre-entry experience, the firms with the characteristics of *de alio* have 1 for variable pr and the firms with those of *de novo* have 0 for variable pr. The research assumed that if a new firm belongs to a corporate group, it has characteristics of *de alio* and can receive the R&Cs from its parent company, and if not, it has characteristics of *de novo*, that is, a new business with its own R&Cs.

As for post-entry effort, the effects were analyzed by looking at the growth rate of tangible assets, the growth rate of R&D intensity and the growth rate of employees. If each growth rate is higher than the average growth rate of firms in the same industry, the research considers that the strength of post-entry effort caused by the post-entry activity is high and when the strength is high, the dummy variables (po_ass, po_rnd, po_emp) become 1. That is, the firm with high growth rate of tangible assets has 1 as variable po_ass; otherwise, it has 0 as variable po_ass. The same method was applied to variable po_rnd representing R&D intensity growth rate and variable po_emp representing the growth rate of employees (human resources).

The duration of the post-entry effort was limited to 4 years after the firm's establishment and the increase/decrease of experience was calculated on average.

In order to measure the short and long-term result of a firm, a dummy variable (t) was used to represent the period. For short-term (4 years or less), the variable t is 0 and for the long-term, of a firm between 7 and 10 years old, variable t is 1.

The research analyzed the impacts of pre-entry experience and post-entry effort on the sales growth rates of firms for both short-term and long-term, and at the same time, to analyze the results of the two experiences' mutual operations the research studied pre-entry experience, post-entry effort, three dummy variables representing terms, and other dummy variables of crossed items. To measure pre-entry experience, post-entry effort, and coefficient values of three main dummy variables related to period and statistical significance, the analysis used the model of triple difference (difference in difference in difference).

Triple difference has the advantage of verifying the significance of not only of the coefficient values ($\beta1 \sim \beta3$) of three main dummy variables, but also the coefficient values ($\beta4 \sim \beta7$) of the respective interaction dummy variables as given in equation 14. The interaction variables (pr x po_ass, pr x po_rnd or pr x po_emp) of pre-entry experience and post-entry effort are independent variables and they function as important control variables necessary to determine whether the factors influencing growth of firms are inherited R&Cs or nurtured R&Cs. Natural logarithm value of the sales of the applicable previous year was used as controlled variants of the firm size, and R&D investment for the previous year were used as control variables.

The result of the Hausman test confirmed the endogeneity between the main independent variables and error terms. To solve this, regression analysis was conducted with a model of Hausman and Taylor which enabled the gain of a consistent estimator from the panel data (Hausman and Taylor, 1981). In this type of research where a dummy variable is a main independent variable, this model is useful as it identifies the coefficients of dummy variables that are omitted in the analysis with the fixed effect model and verifies their significance.

The equations of the main d in d in d (triple difference) models are as follows (inferior letter i: firm, t: time):

$$y_{it} = \beta_0 z_{it} + \beta_1 pr_i + \beta_2 po_i + \beta_3 t \qquad \text{Eq. (14)}$$

$$+\beta_4 (pr{\cdot}t)_{it} + \beta_5 (po{\cdot}t)_{it} + \beta_6 (pr{\cdot}po)_i + \beta_7 (pr{\cdot}po{\cdot}t)_{it} + \varepsilon_{it}$$

y_{it} : firm's sales growth rate

pr_i : pre-entry experience or not

po_i : post-entry effort or not

(degree of experience for 4 years after the establishment)

t : long-term result of sales growth rate or not

z_{it} : other control variables – firm size, sales , tangible assets, etc.

$(pr{\cdot}t)_{it}$: interaction variables of variable pr and variable t

$(po{\cdot}t)_{it}$: interaction variables of variable po and variable t

$(pr{\cdot}po)_i$: interaction variables of variable pr and variable po

$(pr{\cdot}po{\cdot}t)_{it}$: interaction variables of variable pr, variable po and variable t

In the model of Eq. (14), depending on the type of post-entry effort, po_ass, po_rnd, or po_emp was used. Table 15 explains the variables used in this research.

Table 15. Definition of variables in post-entry effort studies

Key variables	Definition
y	Firm's sales growth rate, y_{it}= $\ln S_t$-$\ln S_{t-1}$, (S_t: sales of the applicable year, S_{t-1}: sales of the previous year)
pr	Pre-entry experience or not (*de alio* or *de novo*) – 1 for a firm affiliated with a corporate group and 0 for others
po_ass	1 if the average growth rate of the tangible asset for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
po_rnd	1 if the average growth rate of R&D intensity for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
po_emp	1 if the average growth rate of human resources for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
t	For the first 4 years after establishment t=0 (short-term), between 7 years and 10 years t=1 (long-term).
pr x t	Interaction dummy variable of variable pr and variable t
po_ass x t, (po_rnd x t, po_emp x t)	Interaction dummy variable of variable po_ass and variable t (the same method is applied to variable po_rnd and variable po_emp)
pr x po_ass, (pr x po_rnd, pr x po_emp)	Interaction dummy variable of variable pr and variable po_ass (the same method is applied to variable po_rnd and variable po_emp)
pr x po_ass x t, (pr x po_rnd x t, pr x po_emp x t)	Interaction dummy variable of variable pr, variable po_ass and variable t (the same method is applied to variable po_rnd and variable po_emp)
L.ln_sales	Natural logarithm value of the sales of the applicable previous year (applying GDP deflator)
L. rnd_int	R&D intensity value of the previous year

5.4 Empirical analysis

5.4.1 Results of descriptive statistical analysis

Empirical was conducted on Korean manufacturing firms established between 1997 and 2000. By using the unbalanced panel data activities of 1,080 firms (3,063 for the number of observed targets) between 1997 and 2009, the research conducted regression analysis.

Table 16 shows the number of observed targets and the total ratio in order to figure out the ratio between pre-entry experience and post-entry effort. As is evident from Table 16, *de novo*, without pre-entry experience shows more number of observed targets, (about 1.6 times) than *de alio*. Additionally, new firms, regardless of pre-entry experience, show intense R&D activities and employees' post-entry effort, and a comparison of the numbers of observed targets verified that the investment was not very active in the case of tangible assets. Overall, while *de novo* shows on average 1.6 times more observed targets than *de alio*, post-entry effort of tangible assets shows twice the number of observed targets. It proves that right after the establishment *de novo* extends tangible assets more than *de alio*.

Table 17 shows that for post-entry effort of tangible assets, the number of observed targets, average value, the correlation matrix equivalent to standard deviation for main variables and main dummy variables, and the overall ratios can be verified through the mean value and the same number was shown in Table 16.

Except for the correlation between the firm size and the interaction variables, it was verified that the crossed correlation among variables is not very high and other post-entry efforts showed values similar to those of tangible assets.

Table 16. The number of observed targets and total ratio of pre-entry experience and post-entry effort

Pre-entry experience	Post-entry effort						
	Tangible assets		R&D intensity		Employee		
	Weak	Strong	Weak	Strong	Weak	Strong	Total
De novo	1,278	627	733	1,172	728	1,177	1,905
	(41.7)	(20.5)	(23.9)	(38.3)	(23.8)	(38.4)	(62.2)
De alio	831	327	460	698	454	704	1,158
	(27.1)	(10.7)	(15.0)	(22.8)	(14.8)	(23.0)	(37.8)
Total	2,109	954	1,193	1,870	1,182	1,881	3,063
	(68.9)	(31.2)	(39.0)	(61.1)	(38.6)	(61.4)	(100.0)

Frequency percentage in parentheses

Table 17. Descriptive statistics for variables in post-entry effort studies

		Obs.	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	y	3063	0.129	0.397	1.000									
2.	L.ln_sales	3063	16.571	1.428	-0.292	1.000								
3.	L.ln_rnd	3063	12.780	1.760	-0.053	0.371	1.000							
4.	pr	3063	0.378	0.485	-0.031	0.274	0.175	1.000						
5.	po_ass	3063	0.311	0.463	0.024	-0.058	-0.017	-0.049	1.000					
6.	t	3063	0.810	0.393	-0.209	0.342	0.166	0.011	-0.008	1.000				
7.	pr x t	3063	0.308	0.462	-0.101	0.332	0.194	0.856	-0.043	0.324	1.000			
8.	po_ass x t	3063	0.251	0.434	-0.059	0.065	0.049	-0.038	0.860	0.281	0.048	1.000		
9.	pr x po_ass	3063	0.107	0.309	-0.021	0.075	0.083	0.443	0.514	0.003	0.378	0.449	1.000	
10.	pr x po_ass x t	3063	0.087	0.282	-0.075	0.136	0.106	0.396	0.459	0.150	0.462	0.533	0.892	1.000

5.4.2 **Results of regression analysis**

Tables 18–20 show the regression analysis results for each type of post-entry effort. Overall, as the size of a firm is less, the growth rate of sales rises.

As known from the basic model of Model (1), the growth rate of sales was positively impacted by the pre-entry experience. However, when the growth rate of tangible assets was high, there was no significant impact on the growth rate of sales, as in the case of firms with strong post-entry effort.

The extended Models (2)–(4) show the analyses results with the addition of interaction variables as control variables. For the pre-entry experience, the long-term growth rate cannot be verified for the statistical significance level (variable pr x t) except for the low-tech. That is, it is difficult to decide whether inherited R&Cs are useful for the growth of long-term sales.

For pre-entry experience with strong post-entry effort (variable pr x po_ass), that is, if the firms with large inherited R&Cs increase their nurtured tangible assets intensely, there is a negative insignificant impact on the growth rate of sales. The caution is that, in this case, the post-entry effort of *de alio* firms gives a negative insignificant impact on the growth rate of long-term sales (variable pr x po_ass x t) in Model (2) and Model (3). It is estimated that since tangible assets are machines, facilities, devices, and so on, resourceful *de alio* firms can easily secure these. Therefore, tangible assets whose sizes become bigger turn into obstacles to environmental changes and interfere with the firm's growth rate, especially in high-tech industry.

Table 19 shows the effects of post-entry effort of R&D intensity.

Model (5) shows that a *de alio* firm's sales growth rate is positively impacted, and the extended models (Models (6)–(8)) controlling crossed variables show the same result. Firms with strong R&D intensity in post-entry effort witness a negative impact on the growth rate of sales. In the analysis of adding crossed variables as control variables, like Model (6) and Model (7), it is verified that higher increasing of R&D intensity post-entry effort decreases the growth rate of sales (variable po_rnd). However, from a long-term perspective, as the negative value changes to positive, it boosts growth rate of sales (variable po_rnd x t). This result showed a significantly meaningful result of confirming the fact that post-entry efforts showed effects that differed between short-term results and long-term results.

R&D intensity is a representative intangible asset, and it creates a new long-term alternative for the innovation and evolutionary development of a firm. Therefore, as March (1991) explains, the evolutionary development of a firm is dependent on the concepts of local exploitation and extensive exploration. The research similarly shows that R&D activities do not provide good causes for the short-term effects, but do provide positive causes for the long-term effects, such as extensive exploration.

Finally, Table 20 shows the result of employees' post-entry effort.

Model (10) shows that the firms with strong human resources in post-entry effort demonstrate high growth rate of sales (variable po_emp). This verifies that human resources in post-entry effort is effective in raising the short-term growth rate of sales, which is changed to the negative effect on the long-term results (variable po_emp x t). This result shows the opposite result to that of R&D intensity in post-entry effort. This demonstrates that the effects vary depending on the type of post-entry effort.

Model (10) and Model (11) show that significant results could be retrieved on the common effects of pre-entry and post-entry efforts in the short-term growth rate of sales. In the analysis of adding crossed variables as control variables, like Model (10) and Model (11), it is verified that higher increasing of employee's post-entry effort of a *de alio* firm decreases the growth rate of sales (variable pr x po_emp). However, from a long-term perspective, as the negative value changes to insignificant positive, it means that effect of a *de alio* firm's post-entry effort disappears in the long-term (variable pr x po_emp x t).

Employee (human resources) is used as a variable to measure the size or growth of a firm, sales and total assets, and innovation. Innovations are theoretically categorized into product innovation and process innovation, wherein product innovation requires more employees and process innovation reduces the number of employees due to enhancement of productivity. However, the empirical studies show mixed results in terms of the relation between innovation and employment growth (Evangelista and Savona, 2003; Hall et al., 2008).

The research considered the variable employee as a concept of input mixed with tangible assets and R&D intensity and conducted an empirical analysis on the effects of its output, the growth rate of sales. As known from the result, the effect of employee's post-entry effort on sales growth is different from that of R&D intensity in post-entry effort. Additionally, when firms respond to market situations initially and expand the employee base (human resources), the new employees might adapt to the new environment, and this can support the firms' growth in the short-term.

As for tangible assets, post-entry effort shows significant value only in the low-tech industry, and in the long term, it shows a negative impact on the growth rate of sales. As for employee post-entry effort, it shows a negative impact on the long-term growth rate of sales, and only R&D activities in high-tech have a positive impact in the long term.

The long-term effect of R&D post-entry effort showing significant results in regression analysis is clearly demonstrated in the high-tech industry. This is because high-tech industries are exposed to a more abruptly changing environment and intellectual assets are required. Thus, post-entry effort is a very important factor for their growth. This result demonstrates that structural inertia is created from the initial experience of a new firm and, therefore, it is important to build good structural inertia early and the long-term effects vary depending on the type of industry and the type of entry experience.

Table 18. Regression results according to tangible assets- based efforts

	Model (1)	Model (2)	Model (3)	Model (4)
VARIABLES	Baseline of Tangible assets	Overall in Manufacturing.	High-tech. in Manufacturing	Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.266***	-0.261***	-0.301***
	(0.013)	(0.013)	(0.015)	(0.030)
L.ln_rnd	0.002	0.004	-0.001	0.016
	(0.008)	(0.008)	(0.010)	(0.011)
t	0.121***	0.136***	0.109***	0.263***
	(0.024)	(0.032)	(0.038)	(0.053)
pr	0.201***	0.265***	0.211***	0.474***
	(0.030)	(0.049)	(0.058)	(0.089)
pr x t		-0.048	-0.005	-0.213***
		(0.042)	(0.051)	(0.065)
po_ass	-0.004	0.040	-0.003	0.202**
	(0.029)	(0.050)	(0.060)	(0.085)
po_ass x t		-0.008	0.053	-0.230***
		(0.045)	(0.055)	(0.068)
pr x po_ass		-0.067	-0.023	-0.169
		(0.084)	(0.099)	(0.159)
pr x po_ass x t		-0.053	-0.113	0.122
		(0.075)	(0.089)	(0.123)
Constant	4.405***	4.262***	4.261***	4.609***
	(0.204)	(0.206)	(0.237)	(0.468)
Wald chi2 (d.f.)	602.39 (5)	602.88 (9)	474.97 (9)	131.36 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 19. Regression results according to R&D intensity- based efforts

VARIABLES	Model (5) Baseline of R&D intensity	Model (6) Overall in Manufacturing.	Model (7) High-tech. in Manufacturing	Model (8) Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.263***	-0.257***	-0.310***
	(0.013)	(0.013)	(0.015)	(0.032)
L.ln_rnd	0.003	-0.004	-0.011	0.010
	(0.008)	(0.008)	(0.011)	(0.011)
t	0.121***	0.081**	0.066	0.163***
	(0.024)	(0.035)	(0.042)	(0.062)
pr	0.200***	0.269***	0.247***	0.404***
	(0.029)	(0.056)	(0.065)	(0.118)
pr x t		-0.078*	-0.065	-0.139*
		(0.046)	(0.055)	(0.076)
po_rnd	-0.020	-0.128***	-0.128**	-0.136
	(0.028)	(0.049)	(0.060)	(0.087)
po_rnd x t		0.137***	0.156***	0.064
		(0.044)	(0.054)	(0.070)
pr x po_rnd		-0.041	-0.081	0.037
		(0.078)	(0.093)	(0.144)
pr x po_rnd x t		0.035	0.063	-0.029
		(0.069)	(0.084)	(0.109)
Constant	4.405***	4.370***	4.368***	4.959***
	(0.205)	(0.200)	(0.228)	(0.494)
Wald chi2 (d.f.)	603.46 (5)	646.73 (9)	515.43 (9)	124.85 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 20. Regression results according to employee-based efforts

VARIABLES	Model (9) Baseline of Employee	Model (10) Overall in Manufacturing.	Model (11) High-tech. in Manufacturing	Model (12) Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.265***	-0.259***	-0.299***
	(0.013)	(0.013)	(0.015)	(0.031)
L.ln_rnd	0.002	0.007	0.000	0.017
	(0.008)	(0.008)	(0.010)	(0.011)
t	0.121***	0.177***	0.168***	0.240***
	(0.024)	(0.039)	(0.045)	(0.070)
pr	0.201***	0.339***	0.323***	0.458***
	(0.030)	(0.064)	(0.073)	(0.134)
pr x t		-0.070	-0.069	-0.097
		(0.054)	(0.063)	(0.093)
po_emp	-0.004	0.113**	0.119**	0.109
	(0.027)	(0.049)	(0.058)	(0.093)
po_emp x t		-0.080*	-0.076	-0.113
		(0.045)	(0.054)	(0.075)
pr x po_emp		-0.159**	-0.202**	-0.087
		(0.079)	(0.093)	(0.150)
pr x po_emp x t		0.011	0.049	-0.080
		(0.070)	(0.084)	(0.114)
Constant	4.406***	4.158***	4.155***	4.588***
	(0.206)	(0.208)	(0.240)	(0.477)
Wald chi2 (d.f.)	606.06 (5)	611.95 (9)	479.38 (9)	127.36 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.5 Summary

The result of the empirical analysis demonstrates that pre-entry experience and post-entry effort have various impacts on the growth of firms. This research provides important clues in understanding whether the R&Cs that lead to growth of firms are derived from the pre-entry or post-entry effort.

The validities of natural R&Cs disappear as time goes by. This satisfies hypothesis 1, which states that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate. Inherited R&Cs can be effective on short-term results; however, as time goes by and environmental changes occur, the firms dependent only on inherited R&Cs do not eventually adapt to these changes and consequently generate insufficient result in the long-term. This result is similar to the organization ecology perspective in which firms not able to adapt to the environment perish.

On the other hand, nurtured R&Cs do not lose their validity and have long-term impacts on the firm. This confirms hypothesis 2a, which states that post-entry effort influences both short-term and long-term growth rates

This aligns with the evolutionary economy perspective in which the initial efforts of firms make the surrounding environment, and the structural inertia of organizations capable of adapting to the environment is re-built, and eventually, the firms adapt to the market actively. According to the non-/existence of pre-entry experience, the post-entry efforts show different impacts on short and long-term results. In high-tech industries, the discrepancy of this effect is obvious, because natural R&Cs gained from pre-entry experience are likely to be independent of the market or the competing environment, while nurtured R&Cs by post-entry effort are likely to be the ones that firms secure considering the market environment, competitors' activities, and firms' situations in the adapting process of evolution.

During the firms' adaption to the internal and external environments, the initial structural inertia is not changed easily; thus, the short-term result can be the opposite of the long-term result.

This research verified that, depending on the type of the nurtured experience, local short-term effects and extensive long-term effects are differently generated. March's argument (1991) that parallel implementation of exploitation and exploration is the most effective way is yet be verified; nevertheless, it is understood that nurtured R&Cs enable firms to evolve by directing various experiences in parallel.

In the case of R&D intensity and human resources, the long term effects from their mutual operation of pre-entry experience and post-entry effort were not significant on the growth of firms; thus, it is understood that each experience is independent, and the effect is generated when they mutually operate.

The present research is a novel trial, differentiated from other existing researches in that it divided the R&Cs that were believed to be the original power of the firm's growth into the inherited, natural ones before the entry and the raised, nurtured ones after the entry and verified whether each had an effect on the long-term growth of a firm through empirical analysis. By verifying that the initial entry experience causes structural inertia, which consequently impacts the future growth of a firm, the research conducted a dynamic trace on the conventional argument from the resource-based perspective and the evolutionary economics theory that the initial entry experience is an important factor. This demonstrates that this research has an academic significance concerning the dynamics of firms.

The result of the research suggests that firms' management executives consider strategic decisions that firmly delineate the pre-entry experience and post-entry effort of new firms.

Additionally, in the beginning of the business, good structural inertia strategy is more important than extending the firm's size. The research also provides a logical argument to the policy-makers such that, because the incubation period when firms can experience trials and errors is very important, governmental financial and institutional support should be strategically designed to augment the future growth of firms by facilitating the nurture of post-entry R&Cs.

Chapter 6. Conclusions and implications

The present research sought to clarify factors affecting firm growth with regard to R&Cs. Specifically, this thesis focused on two classes of R&Cs (pre-entry and post-entry) that influence firms' growth prospects. The relationship between the state of firms upon market entry and the future growth of firms was also analyzed.

6.1 Conclusions of inherited (natural) resources and capabilities

The results of the effects on the R&Cs are studied through the *de alio* and *de novo* categorization of market entrants. It has been expected that, on average, *de alio* firms tend to have a larger sales-size than *de novo* firms, and *de novo* firms have a higher R&D intensity than *de alio* firms. In addition, this research has confirmed that *de alio* firms enter the market with higher levels of R&Cs due to the pre-entry experience, and *de novo* firms have a higher potential of technology innovation. Moreover, it has been also shown that, in reality, *de novo* invests more in R&D.

In terms of the firm's growth, *de alio* firms with the sufficient R&Cs have higher growth rates than *de novo* firms do, which is similar to the findings of previous related studies. However, the important focus of this research was to determine whether, how long, and to what extent this phenomenon continues. As a result, it demonstrates that the gap of characteristics between *de alio* and *de novo* firms decreases over time. After a certain period of time, a *de alio* firm with the pre-entry experience does not continue to have the same growth rate, which means that as the time passes, the inherited R&Cs do not significantly affect the firm's growth. Specifically, it was found that four years after market entry, the gap of sales growth rate between *de alio* and *de novo* firms is concretely decreased.

In the organization ecology perspective, a *de alio* firm, with the sufficient natural R&Cs inherited from the pre-entry experience, is more likely to be selected by the initial environment. As a result, the short-term growth rate is high. However, the natural R&Cs received from the parent firm have positive impacts on the growth and survival of firms in the beginning of the business.

However, of course, the firm should continue to undertake effort to obtain distinctive R&Cs, as no R&Cs can last forever. These kinds of effort are called the post-entry efforts for adapting to in environment according to the "Variation–Selection–Retention–Competition" process of the evolutionary economics perspective.

6.2 A comparison of the resources and capabilities

The firm's R&Cs created by pre-entry experience and post-entry effort, and their effects on firms' growth are summarized below:

First, R&Cs that lead to the firm's growth are generated through both pre-entry experience and post-entry effort. However, the effects of the pre-entry experience decline as time passes. Therefore, the effects of pre-entry experience are more conspicuous on the short-term growth rate than those on the long-term growth rate. This demonstrates that natural R&Cs can affect the short-term performance of the firm. However, the firms that just depend on natural R&Cs might fail to respond to environment changes in a timely manner, and it also leads to the failure of their long-term performance. From the organization ecology perspective, the firms that are not appropriate to the environment become extinct. This states that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate.

Second, the effects of post-entry experience have an impact on a firm's long-term performance. This confirms that the nurtured R&Cs do not lose their validity and do have an impact on the firm's long-term performance. Moreover, the nurtured R&Cs have an impact on a firm's short-term performance in the firm's initial stage of adapting to the environment. At the same time, the structural inertia generated during the adaptation process becomes routine, and it also has an impact on a firm's long-term performance. This proves that post-entry effort influences both the short-term and long-term growth rates. Therefore, the evolutionary economics with the perspective of active adaptation to the market and the resource-based view provide the same interpretation.

Third, this research has confirmed that the result of nurtured R&Cs are accumulated from different efforts, and each of has a different impact on the firm's short-term and long-term performances. Depending on the type of R&Cs, some are favorable for the short-term performance but unfavorable for the long-term performance, and vice versa. Most R&D activities are unfavorable for the short-term performance but favorable for the long-term performance. However, the efforts for increasing human resources have opposite results. These patterns are particularly obvious in the high-tech industry. Unlike the natural R&Cs that are inherited regardless of the market or competition environment, the nurtured R&Cs are created by post-entry efforts. This effort is accumulated as the firms experience the market environment, competitors' trends, and various challenges. These are larger in the high-tech industry, which undergoes severe environmental changes and competition. Generally, R&D activities should be invested for their long-term effects rather than their short-term effects.

However, increasing human resources for the sake of short-term performance will hinder the development of the adequate human resources while the environment changes and existing human resources become an obstacle due to the structural inertia that hampers adaptation in the long-term.

During the firms' adaptation to internal and external environments, the initial structural inertia does not easily change and, thus, the short-term result can be the opposite of the long-term result.

This research verifies that, depending on the type of nurtured experience, local short-term effects and extensive long-term effects are generated.

6.3 Implications

This research is a novel trial and can be differentiated from previous studies, in that it categorizes the R&Cs that were believed to be the original source of a firm's growth into inherited "natural" ones before entry and cultivated "nurtured" ones after entry. Moreover, empirical analysis was employed to verify whether each had an effect on the long-term growth of a firm. In particular, by verifying that the initial entry experience causes structural inertia, this research is a dynamic investigation of the conventional argument found in the resource-based perspective and the evolutionary economics theory. The structural inertia has a consequent impact on the future growth of a firm, and the initial entry experience of a firm is an important factor. This demonstrates that this research is of academic significance to the literature on firm dynamics.

As shown in the result of the research, there are different capabilities favorable for short-term performance and long-term performance. Depending on the firm's focus, the long-term performance can be different in terms of the specific firm's financial result. It provides an important strategic implication in addition to March's exploration/exploitation theory. That is, the development of a firm's R&Cs should be continued considering a long-term perspective, despite side-effects in the beginning.

The result of this research proposes that firms' managers should consider a new business in terms of the various strategic decisions on the pre-entry experience and post-entry effort, and especially in the beginning of the business, the managers should be advised that establishing a good structural inertia is more important than extending the size of the firm.

In addition, this research proposes a logical principle to policy-makers. The incubation period is crucial since the firms can experience trial and error during that period. Therefore, governmental support for new firms should be strategically offered to augment future growth.

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Appendix 1: Estimation result of the quantile regression model

Estimation result of the quantile regression model (≤ 3rd year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Estimation result of the quantile regression model (4^{th}~6^{th} year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Estimation result of the quantile regression model (≥7th year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Abstract (Korean)

신생기업은 설립 이전의 경험(pre−entry experience)에 의해 전해지는 자원과 역량뿐만 아니라 설립 직후 여러 가지 경험(post−entry effort)에 의해 육성되는 자원과 역량에 의해서 성장해 나간다.

본 연구의 목적은 기업이 설립 직전 또는 설립 직후에 얻은 자원과 역량이 기업의 장기 성과에까지 영향을 미치는가를 파악하는 것이다. 이를 위해, 설립 이전의 경험(pre−entry experience)이 선천적(nature)으로 이어받는 자원과 역량(resources and capabilities)을 만들고, 설립 직후의 노력(post−entry effort)이 후천적(nurture)으로 육성 되는 자원과 역량(resources and capabilities)을 만들 것으로 판단하고, 설립 이전의 경험 유무와 설립 직후의 경험 강도를 측정하였다. 이와 같이 다른 종류의 경험이 기업의 성장경로에 미치는 효과를 보기 위해 기업의 성장률을 단기와 장기로 나눠서 동태적인 분석을 실시하였다.

우선, 선천적 경험의 효과를 확인하기 위해 디알리오(de alio) 및 디노보(de novo) 연구를 실시하였다. 선천적 경험의 효과를 극대화하기 위해서 신규산업인 신/재생에너지 산업을 대상으로 실증분석을 실시하였다. 선천적 경험이 있고 없음을 갖고 디알리오와 디노보로 구분할 수 있는데,

선천적 경험이 있는 디알리오가 매출 규모가 크고 단기 성장률이 높은 것으로 확인되었으며, 선천적 경험이 없는 디노보는 R&D 집적도가 높게 나는 것으로 확인되었다. 그러나 일정 기간이 지난 후에는 선천적 경험의 효과가 사라지면서 디알리오와 디노버의 특징이 없어짐을 확인하였다.

또한, 선천적 경험과 후천적 노력의 단기 및 장기 효과를 상호 비교하기 위해서 국내 제조산업을 대상으로 연구를 실시하였다. 단기 및 장기 효과를 비교한 실증분석 결과에서는 신생기업의 선천적 경험(pre−entry experience)보다는 후천적 경험(post−entry effort)이 장기 성장률에 더 강하게 영향을 미치고 있음을 확인하였다. 후천적 경험 중에서 R&D집중도는 High−tech. 산업에서 기업의 단기 성장률에는 부정적인 영향을 줄 수 있지만, 장기 성장률에는 긍정적인 영향을 주는 것으로 확인되었으며, 또 다른 후천적 경험인 인력자원(employee)의 증강은 이와는 반대로 전반적으로 장기적 성과에 부정적인 효과가 나타나는 것으로 분석되었다. 또한 선천적 경험은 전반적으로 기업의 장기 성장에는 영향을 못 주는 것으로 나타나며, 선천적 경험과 더불어 유형자산의 증가를 후천적으로 강하게 경험한 기업의 경우에는 Low−tech. 산업에서 장기 성장률에 영향을 미치되, 부정적인 효과를 보이는 것으로 확인되었다.

본 연구에서는 선천적 경험과 후천적 노력이 신생기업의 성장에 영향을 미치고 있으며, 선천적 경험의 효과는 시간이 지나면서 그 유효성이 점차

사라짐을 증명하였다. 반면, 후천적 노력의 효과는 기업의 장기 성과에도 영향을 계속해서 끼치는 현상을 밝힘으로써 기업 초기의 노력이 주변 환경과의 적응을 통해 조직의 루틴을 만들어가는데 매우 중요한 활동임을 보여주었다. 이는 사업 초기의 전략과 정책이 기업의 미래 성장을 결정지을 수 있다는 경영전략적 정책적 함의를 제공하는 중요한 연구성과가 될 것으로 기대한다.

주요어 : 선천적 경험, 후천적 경험, 기업 성장, 자원과 역량, 신생기업, 디알리오, 디노보

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Nature versus Nurture in Resources and Capabilities on the Firm Growth

- An Empirical Study of the firm growth -

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Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

Keunseob, Choi

Nature versus Nurture in Resources and Capabilities on the Firm Growth

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Abstract

Nature versus Nurture in Resources and Capabilities on the Firm Growth

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The present research seeks to clarify factors affecting firm growth with regard to resources and capabilities (R&Cs). Specifically, this thesis focuses on two classes of R&Cs that influence firms' growth prospects: pre-entry R&Cs and post-entry R&Cs. The relationship between the state of firms upon market entry and the future growth of firms is also analyzed.

This study divides the R&Cs that are crucial to a new firm's growth into two categories analogous to the concepts of nature and nurture in human developmental studies: (1) inherited "natural" R&Cs that are present before the firm's market entry and (2) cultivated, "nurtured" ones that are acquired after the entry. The study seeks to verify whether and to what extent each has an effect on the long-term growth of the firm. This nature/nurture approach is considered and elaborated in a literature review of selected theories and related empirical findings, which are integrated to derive a novel

methodology for the analysis of growth-affecting factors through time for new market entrants. This is applied in two research efforts.

The first research element (Chapter Four) is focused on the effect of pre-entry experience. The aim of the first research element is to examine whether *de alio* or *de novo* firms achieve faster sales growth, and how long the effects of these respective entrance conditions persist, when they enter the new and renewable energy industry. Firms that have just entered new markets can be distinguished as either those with pre-entry experience in other areas (*de alio*), or those without such pre-entry experience (*de novo*). *De alio* firms tend to enter markets under conditions that are advantageous in light of their pre-entry experience; on the other hand, *de novo* firms tend to enter markets with innovation capabilities. Therefore, this study identifies and compares growth patterns of *de alio* and *de novo* firms over a period following market entry. This is undertaken by means of panel data for global companies that entered the new and renewable energy industry after the 1990s.

The results show that *de alio* firms achieved higher growth rates than *de novo* firms in the initial stages following entrance but that the entry type's contribution to sales growth gradually decreased, disappearing within four years after entrance. The results indicate that previously accumulated resources and new entrants' former experiences in other industries have positive effects, helping them achieve initial success (for a limited time) after entry into an industry. This suggests that firms adapt the R&Cs that are appropriate for their new environments derived from pre-entry experience for the sake of sustainable development.

The aim of the second research element (Chapter Five) is to compare the effects of pre-entry experience and post-entry effort. Findings demonstrate that nurtured (i.e., post-entry) R&Cs affect a firm's growth rate more than inherited/natural (i.e., originating pre-entry) R&Cs do. The results of the empirical analysis demonstrate that pre-entry experience and post-entry effort have various impacts on the growth of firms. This research provides important clues in understanding whether the R&Cs that lead to growth of firms are from the pre-entry or post-entry effort.

The positive impact of natural R&Cs diminishes as time goes by, which indicates that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate. In other words, natural R&Cs can be effective on short-term results, but as time goes by and environmental changes occur, the firms dependent only on inherited R&Cs do not eventually adapt to these changes, and consequently tend to generate insufficient result in the long-term.

On the other hand, nurtured R&Cs do not lose their validity and have long-term positive effects on the firm, which indicates that post-entry effort influences both short-term and (to a an increasing extent) long-term growth rates.

Depending on the type of efforts, the post-entry efforts show different impacts on short and long-term results. Some are more favorable for short-term performance but unfavorable for long-term performance, and vice versa. Most R&D activities are unfavorable for short-term performance but favorable for long-term performance.

However, the efforts for increasing human resources, for example, have the opposite effect.

In high-tech industries, the discrepancy of this effect is obvious, because natural R&Cs gained from pre-entry experience are likely to be unsuited to the market or the competing environment. Conversely, nurtured R&Cs (by post-entry effort) are likely to be well-suited to the evolving market environment, competitors' trends, and firms' situations.

The results of the research indicate that firms' management executives, when considering pre-entry experience and post-entry effort in strategizing and forecasting growth, should focus on establishing and maintaining good structural inertia more than increasing organizational size.

In addition, the findings can inform the decision-making processes of policy-makers. Since the incubation period, when firms can conduct trial and error-based development, is very important, government support should be designed to augment the future growth of firms by facilitating effective post-entry effort.

Key words: pre-entry experience, post-entry effort, firm growth, resources and capabilities, *de alio* and *de novo*

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Chapter 1. Introduction

“The firms that have differentiated R&Cs can grow, but only the firms that pursue the continuous growth can survive.” This statement is widely accepted by management theorists. It is widely accepted; however, that does not mean that all the firms can grow and survive. Thus, knowing the effects of differentiated R&Cs is important. However, an understanding of how effective R&Cs can be secured and evolved is necessary to achieve success. To implement an effective strategy, it is essential to comprehend the origins R&Cs. In other words, it is necessary to understand the extent to which the present and future growth of firms depend on the inherited (natural) R&Cs or nurtured R&Cs.

The research studies new market entrants in light of the origins of those R&Cs. The research compares the inherited R&Cs received through pre-entry experience and the nurtured R&Cs gained through post-entry effort. The overall aim is to determine how, to what extent, and over what timeframe each type of R&Cs affects firms’ growth.

The theoretical frameworks that the research uses are organization ecology, evolutionary economics, and the resources-based view. This research combines these core theories and analyzes the growth patterns of the newly established firms from this integrated theoretical perspective. Recent research has sought to explain the inception and growth of firms from the combined viewpoint considering selection of organization ecology and adaptation of evolutionary economics (Fortune & Mitchell, 2012); in addition, the resources-based view is a key perspective of evolutionary theory in research on dynamic R&Cs (Fortune & Mitchell, 2012; Helfat, 2007; Helfat & Peteraf, 2003). The convergence of these three viewpoints presents a viable framework for connecting the inherited and nurtured characteristics of the R&Cs to the growth of firms.

There are three core reasons for selecting newly established firms as the research subject. First, inherited R&Cs coexist with nurtured R&Cs in the early stages following market entry. Second, the establishment of a firm provides a fixed point to delineate pre-entry experience and post-entry effort, which facilitates the interpretation of R&Cs in the perspective of "nature and nurture." Third, because the post-entry effort does not have many types, the actual forms of the nurtured R&Cs can be clearly defined.

The nature vs. nurture debate in the field of human development has a long history. Until recently, it was considered to provide a clear insight into the triggers for the human behavior. Likewise, when we see consider R&Cs in their impact on the growth of firms through the lens of nature and nurture, management and policy-makers can gain valuable insight regarding executable and detailed solutions concerning firm growth.

The present research intends to clarify the nature and nurture perspective on R&Cs, facilitating an examination of the relationship between the initial state of the firm and the future growth of the firms by conducting an empirical study of inherited and nurtured R&Cs and their influence on the future growth of firms.

1.1 Motivation, research objectives, and approach of the thesis

1.1.1 New perspectives on firm growth

What types of firms can sustain growth? This is a question of keen interest to many scholars, entrepreneurs, and policy-makers. Systematic research into the growth of firms is widely considered to have begun with Edith Penrose's (1959) *Theory of the Growth of the Firm*, and has continued vigorously to present. The environment surrounding firms continues to demand changes, and those firms succeeding in making those changes survive, while those that do not are removed, further changing the environment. In this cycle, the R&Cs of the firms with strong survival power are reinforced; nevertheless, with the evolution of the business environment, competition threatens stability, and inception, growth, and decline of firms are ongoing. Thus, environment, firms, and R&Cs evolve continuously. As the market environment becomes more complex and uncertain, the factors affecting firms' growth become increasingly diverse and complex.

A firm's future growth is typically determined by how innovative the firm can be, how responsive the firm can be to the environmental change, and how differentiated and competitive the firm's internal capabilities (developed through experience or strategic efforts) are compared to other firms. Unfortunately, the previous study of firm growth focused on the firm's size and age, etc. Therefore, the present research intends to switch the focus from firm's size and age to the origins of the R&Cs, which are the basis of the growth of the firms, and analyze the causes of the growth of the firms in a macroscopic, multi-theoretical perspective, instead of the microscopic and detailed approach taken by existing research.

Focusing on nature vs. nurture in resources and capabilities

Can we predict the future of the firms other than by extrapolating from the size and age of the firm? In other words, can we understand the firm's growth in terms of firms' levels of experience and the nature of their strategies? This is the fundamental question of the research.

This question of whether the fundamental cause of human behavior is genetic or environmental is traditionally referred to as the debate over "nature and nurture." The reason why this long-standing debate between the nativists and empiricists is brought in is that it persists as a relevant analytical framework in various fields. It is a simple dichotomy; however, the research process to prove which side is more influential has provided clear insights and wisdom as to the understanding of human behavior. If firms' activities show similar patterns to human behavior (although the use of this perspective on firm growth may be controversial), then a novel understanding of the causes of firms' growth can emerge in the process of investigating such patterns.

As seen in Figure 1, newly established firms grow gradually through learning by doing with the pre-existing R&Cs, which are either inherited from the parent firms or developed in the course of the firms' activities. Therefore, in order to understand and predict the growth of firms, it is essential to observe how innate R&Cs are created and increased with the new firms' post-entry effort and how can these are linked to the future performance of the firms in more multi-dimensional and dynamic ways.

To comprehend the new firms in a multi-theoretical way, organization ecology (Hannan and Freeman, 1989), evolutionary economics (Nelson and Winter, 1982), and the dynamic resource-based view (Teece et al., 1997) are used in the present study. Organization ecology focuses on how the inherited R&Cs play roles in the environmental selection of firms (Hannan and Freeman, 1977, 1989). Evolutionary economics focuses on how the nurtured R&Cs are adapted in the interaction between firms and environments (Gort and Klepper, 1982; Nelson and Winter, 1982).

New firms have to be selected and adapt at the same time, as Fortune and Mitchell (2012) state; thus, the recently-emerged resource-based theory plays an essential role in combining organization ecology and evolutionary economics with the medium of R&Cs. Here "resources" are defined as the stocks, such as materials and human assets, that firms own or control, and the "capability" is manifested in the process of dealing with the resources effectively while responding to the environment (Amit and Schoemaker, 1993). In this perspective, evolutionary theory concerns how the differences of the firms' capabilities dictate success in response to the evolving environment (Huyghebaert and Van de Gucht, 2004; Mata and Portugal, 2002; Sarkar et al., 2006; Zúñiga-Vicente and Vicente-Lorente, 2006).

As a basis for the application of the nature/ nurture dichotomy in understanding how the process of new firms' securing R&Cs pre- and post-entry is connected to future performance, it is essential to delineate the combined theoretical framework clearly.

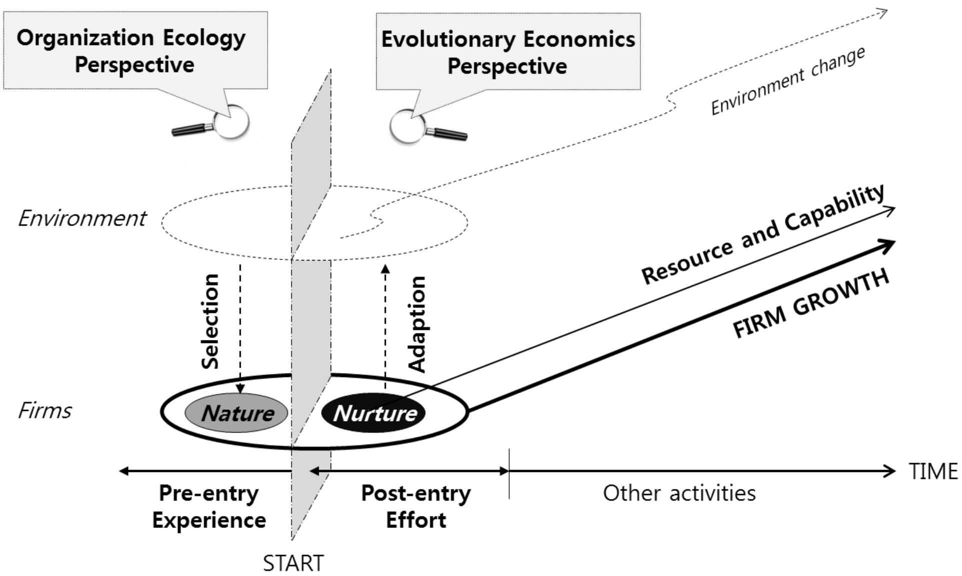

Figure 1. Conceptual diagram: Firm growth patterns and background issues

How to measure resources and capabilities from the nature/nurture perspective

Firms separated from parent firms have inherited R&Cs due to the pre-entry experience of the parent firm, and are thus categorized as *de alio*. On the other hand, start-ups or venture firms have no pre-entry experience, and thus typically have fewer R&Cs; these are categorized as *de novo* firms (Helfat and Lieberman, 2002). Research into the survival and extinction of *de alio* and *de novo* firms is helpful in understanding the influences of “natural” R&Cs on firms’ performance (Barnett et al., 2003; Carroll et al., 1996; Hannan et al., 1998; Hannan and Freeman, 1988; Khessina, 2003; Khessina and Carroll, 2008; Mitchell, 1994; Swanson, 2002).

On the other hand, nurtured R&Cs emerge differently depending on post-entry efforts. Efforts can be considered a proxy of firms' capabilities (Kogut and Zander, 1993; Teece et al., 1997; Zollo and Winter, 2002). Thus, firms accumulate capability through experiences or efforts.

R&Cs can be categorized as nature or nurture by delineating them as pre-entry experience and post-entry efforts, respectively. How these categories of R&Cs are connected to the future growth is analyzed in the present thesis. To see the long-term effects of inherited and nurtured R&Cs, the current thesis considers post-entry effort based on firms' efforts over a certain limited period of time following their establishment as among the capabilities accumulated through learning by doing.

On the firm-level, firms' R&Cs impacts on performance and competitive advantages have been researched in depth in the resource-based view (Barney, 1991; Peteraf, 1993). The resources-based view shows how firms combine and develop their R&Cs in the process of adaptation to the changing environment (Helfat and Peteraf, 2003).

The present research is based on the premise that the future growth of new firms depends on whether they enter the business with R&Cs sufficient to thrive in the new environment or actively increase R&Cs that can be adapted to the environment during the early stages of business development. Therefore, the present research focuses on the process period from the initial stage of a firm to the development stage. To comprehend the effects of the pre-entry and post-entry efforts on the growth pattern of new firms in a dynamic way, the experiences/efforts and the growth of firms are analyzed quantitatively by the use of firms' financial panel data.

Objective of this study

The R&Cs should be considered for the firm's unobserved heterogeneity. The present research aims to prove that pre-entry experience and post-entry efforts contribute to the development the R&Cs that affect the future growth of firms; by viewing the result of this investigation through the lens of nature and nurture, it is hoped that new implications for the growth of firms can be derived to better inform management and policy-makers. This research shows the limitation of the previous firm growth model, which focused on the size and age of firms in predicting growth. The creation and evolution of R&Cs are explained by using the combined theories of organization ecology and evolutionary economics along with a resource-based perspective; this allows the previously ignored role of post-entry efforts to be considered as an explanatory factor. That is, by adding the effect of post-entry effort to the effect of pre-entry experience (that organization ecology has previously focused on), the theories and results that the existing researches have presented can be interpreted from novel perspectives. In addition, new firms' activities can either be negative or beneficial to the future growth of the firms, and the present research is intended to demonstrate this with proofs and analyses.

Structure and methods of the thesis

Chapter Two presents the existing theoretical background of firm growth. In addition, the history and problems of the relationship between theories and models firm growth is explained. To understand the limitations of the growth model, various firm growth theories and models will be reviewed, and criticism of the previous growth theories is presented and discussed.

Chapter Three presents the alternative theoretical framework proposed in the present thesis to analyze the so-called 'nature/nurture' characteristics of the R&Cs under an integrated perspective of organization ecology and evolutionary economics. Simultaneously, the core role of the recent resource-based view in combining these two theories is explained. To assist in understanding the nature/nurture perspective, the relationship between pre- and post-entry efforts and capabilities will be explained with a review of existing literature and previous research results. In addition, among the many factors that determine firms' growth, empirical results concerning some representative factors, such as profit, productivity, innovation, age, size, competition, will be confirmed and compared. It should be understood that these factors are another set of results by the particular R&Cs that the firms have and the characteristics of the R&Cs and their dynamic changes are the major variants of the firms' growth.

Chapter Four presents the analytical findings on how the *de alio* and *de novo* statuses, which have been studied extensively in terms of the effect of pre-entry experience on the growth or survival of firms, have influenced the growth of firms and how long the effects of the pre-entry experiences last. The emergent new and renewable energy sector has with a short history of post-entry efforts; thus, it is a proper industry for understanding the effects of inherited R&Cs gained from pre-entry experience.

Chapter Five presents findings from a direct comparison of the effects of the inherited and nurtured R&Cs. For inherited R&Cs, depending on the existence of pre-entry experience, the concepts of *de alio* and *de novo* are used. For nurtured R&Cs, among the R&Cs that Helfat and Lieberman (2002) categorized. In this study, a representative selection including tangible assets, R&D intensity, and employees is used for measurement of the extent of firms' post-entry effort. The R&Cs can be categorized into core vs. complementary and specialized vs. generalized (Helfat and Lieberman, 2002). Tangible assets are complementary and generalized R&Cs. R&D intensity is core and specialized, and employees would be in the middle of each spectra.

Finally, Chapter Six explains the conclusions drawn from the research review and the empirical results, and implications are drawn for strategic managements and policies making. The nature vs. nurture dichotomy contributed to the understanding of the fundamentals of human beings; it is concluded that this research could initiate an analogous nature vs. nurture dispute to identify factors involved in firm growth and contribute to a better understanding of firm growth per se.

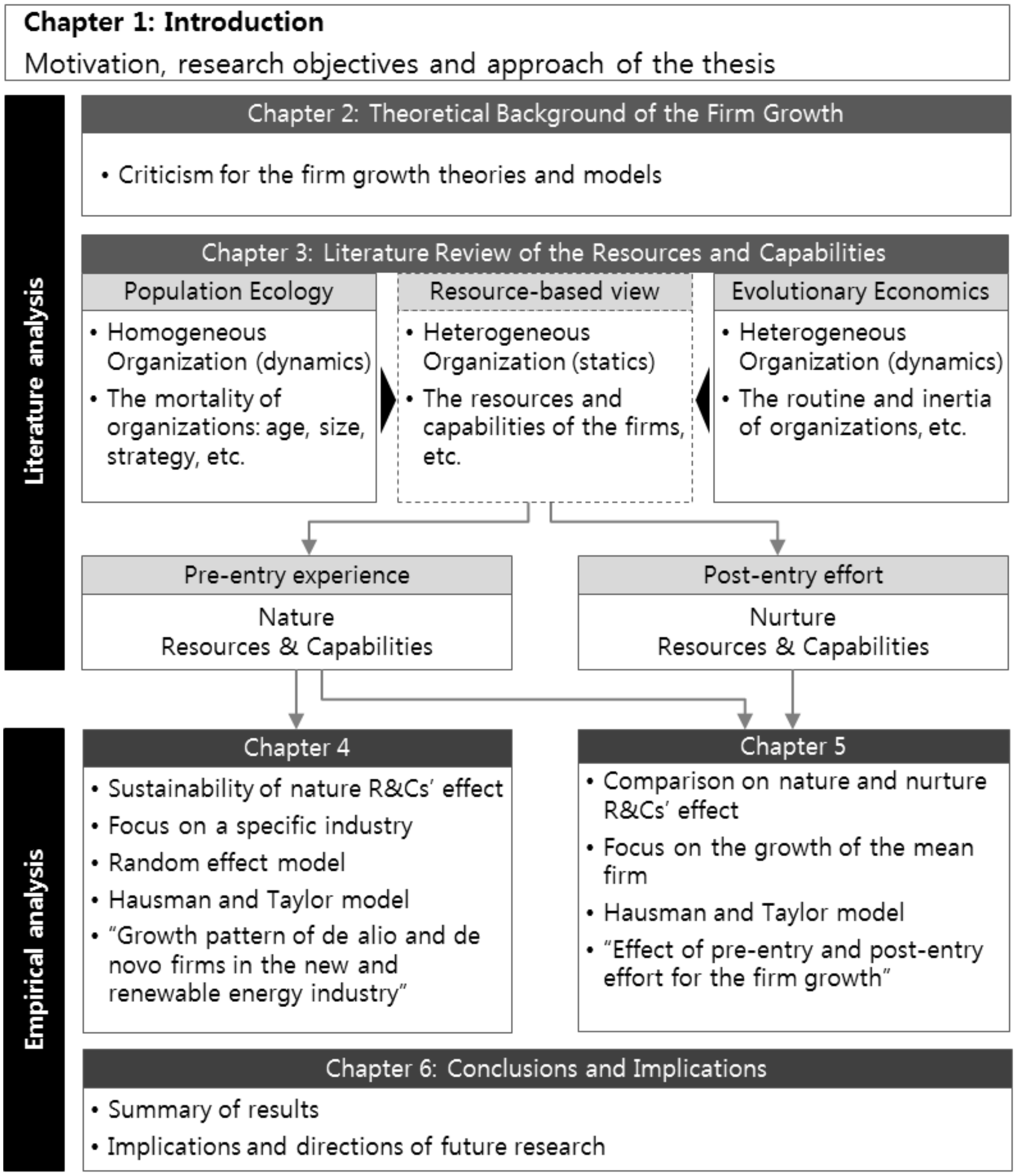

Figure 2. Structure and methods of the thesis

Chapter 2. Theoretical Background of the Firm Growth

2.1 Introduction

The growth theory of firms started with Penrose's (1959) *Theory of the Growth of the Firm* and became a popular research area in economics and business administration. There are many growth theories and related empirical analyses that seek to explain the fundamentals of the growth of economies and firms, including neo-classical growth, endogenous growth, evolutionary economics, and other various growth theories. It is clear that firm growth is directly related to firms' survival, which has an indirect influence on the national economic development. Thus, managers and the policy-makers continue to pay attention to firm growth theory and empirical data. As the types of industries and firms diversify over time and there are frequent births/exits of firms, the growth paths of individual firms are complicated. Multiple empirical analyses have demonstrated patterns in firm growth. However, it is not easy to adequately explain (in one or two factors) growth in firms that have diverse growth paths.

The reason why firm growth continues to receive the attention is that there is discordance between theory and empirical data. The latest growth theory focuses on the firm's internal activities, while the traditional growth model uses firm's external features such as firm's size and age, that are easy to collect as data and have been frequently used as proxy variables in traditional economic growth models. Therefore, there are fundamental differences between traditional and newer growth models.

For example, growth models are designed based on the theories explaining the economic growth. The neo-classical growth theory uses the production function, composed of capital and labor, and the endogenous growth theory adopts knowledge such as technological progress as part of the production function. Since economic growth can be considered as the aggregation of the firm growth and the growth of the economy, firm growth has similar fundamentals to those of economic growth, the similar models can explain both. However, if models are designed by considering firm growth simply in terms of size or age, it is limited in its ability to explain the effects of each firm's idiosyncratic R&Cs, learning abilities, experience and efforts, and routines, all of which determine the pace of firm growth. The firm's unobserved heterogeneity is difficult to explain by the firm's size and age. That is, the firm's growth is influenced by its internal factors, such as firms' internal activities and organizational types as well, as firms' external factors, such as the industry structure and other competitive firms' activities. Therefore, the macro indicators such as size and age are limited in their ability to estimate firm growth dynamically. If the firm growth theory focuses on the firm's actual activities, these should be reflected in the results of the empirical analysis. To do so, it is necessary to develop a model fit the empirical analysis or to develop appropriate proxy variables.

A typical example of the development of the growth model is the endogenous growth theory. In the middle of the 20th century, when the importance of technological change was emphasized, the technological innovation factor entered the economics, developing into the endogenous growth theory. The endogenous growth theory defined technological innovation as “knowledge stock.” Unfortunately, in explaining the accumulation of knowledge, the endogenous growth theory still depends on the R&D investment amount or time variables, which are essentially size and age variables. It is still meaningful that endogenous growth theory applied the accumulation of knowledge to the growth model. However, it is necessary to develop the endogenous growth theory to allow it to use the firm growth model in explaining the firm’s characteristics shown in the knowledge accumulation process, such as the effects of R&Cs influenced by the firm’s internal absorptive capacity, experiences, and other various efforts.

Sizable firms with a diverse range of products are frequently defeated by small firms that have flexible and innovative organizations, often very rapidly. Moreover, firms with the same amount of asset, employee number or age turn out to have different results and sales growth rates. However, the traditional firm growth model focuses rather on the firm’s size variable and age variables, such as assets and employment (that used to be central values in the economic growth theory) rather than firms’ unique features, internal capabilities, efforts, or processes. Thus, it is limited in its ability to explain differences in growth rates. Thus, more theoretical and empirical focuses have been placed on the competitive advantage that individual firms have and how core capabilities make effect on firm growth. In the modern business environment, where technology dependency and competition, and the resulting environmental change, are high, it is not proper to explain the firm’s growth based only on the firm’s external factors such as size or age.

Valid criteria to determine a firm’s future growth should include how innovative the firm can be, how responsive the firm can be to environmental change, and how differentiated and competitive the firm’s internal capabilities, such as experiences or efforts, are against other firms. For researchers, these factors are difficult to define and quantify; however, for the development of the growth theory and model, it is essential to develop similar proxy variables and make the empirical analysis dynamic.

The focus of the current research is not to create a new firm growth theory; rather, it is to assess whether the models used in the previous growth theory or empirical analysis make an actual impact on the firm’s performance and to search for more realistic growth principles that reflect individual firm’s characteristics. Specifically, it is assumed that the R&Cs inherited from the firm’s pre-entry experiences as well as those newly accumulated by means of the efforts immediately after the firm’s establishment have a huge impact on the firm’s growth; thus, the present research intends to apply these explanatory variables, which are not considered in the existing growth model.

Firm growth is not explained by simple and static variables such as tangible assets, including the investment in facilities as a proxy for the firm’s size variable, R&D investment as a proxy for the innovative activity, and the number of employees as a proxy for human capital. It would be desirable to measure how much more effort was made immediately after the firm’s establishment relative to competitors and interpret the firm’s growth theory with these experiences or efforts as variables.

2.2 Firm's growth: Theory and practice

Penrose (1959) proposed the firm's growth theory that was different from the neo-classical economy theory, explaining the firm's growth model using the price and the quantity its products. Penrose argued that the actual firms should be viewed as manageable organizations and the human resources inside the firms can induce or restrict the firms' growth rates. For Penrose, the firm's growth implied that "history matters." That is, for firms, the market opportunities and the services from the firm's resources interact with each other and are accumulated inside the firm. Penrose argued that the growth is the basis of evolution, and the evolution process includes the accumulation of knowledge, which is unique to the firm (Penrose, 1995).

Penrose's perspective on firm growth differed from those of existing industrial economists, which based on the aggregate data. Penrose focuses rather on the internal dynamics and the firm's learning process as the unit of analysis. However, there is a difference between a theory and an actual learning model. The econometric model is a simple model based on the substantial assumption and has restrictions in explaining the firm's actual growth and survival. For example, Jovanovic's learning model does not reflect technological progress and assumes that the changes of all demands are predictable (Jovanovic, 1982). It is true that there is still such a gap in reality if accepting Penrose's position.

Penrose's argument later became the basis for the resource-based view. Since then, various management theories have been introduced that consider the origin of the firm's growth to include the firm's idiosyncratic efforts, the firm's accumulated R&Cs, and the firm-specific competence combined with these two factors. However, in actual empirical analyses, it seems that even Penrose herself did not reflect the theory adequately in the model. It was asserted that the firm-specific resources, capabilities, experiences, efforts, and technologies were not sufficiently used as variables or causes in considering firm growth (Garnsey, 1998).

In the resources-based view, firms locate their positions in their surrounding environment through the interactions between R&Cs and customers, distributors, suppliers, and competitors. In these interactions, firms build tangible assets such as equipment or buildings as well as intangible assets, such as specialization or reputation, and continue to grow. Therefore, the collectable data, such as assets or employee members, become the standard for measuring growth, and the uncollectable data, such as problem-solving capabilities, learning abilities, experiences, or knowhow, which significant impacts on the actual growth of firms, cannot be utilized in the empirical analysis.

In the course of explaining the interest in the firm's entry and exit and its evolutionary process, the interest in individual firms was naturally changed to the interest in the aggregate data, such as population and the fitness distribution between firms and populations. Even organization ecology, the representative evolutionary theory, becomes unduly focused on the firm's survival and exit rather than the firm's growth through the aggregate data (Hannan and Carroll, 1992).

Another evolutionary theory, evolutionary economics, explains the firm's growth differently from Penrose's theory. It considers firms' rather than individuals' actions as key factors. The individuals' actions are seen to be determined by their firms. Thus, the focus is on the firm rather than on the individuals. As a result, the growth of small-sized firms (such as new firms) that have impacts from the individual-level, including the entrepreneur's characteristics, does not seem to be considered adequately in evolutionary economics. In particular, new firm's financial performance fluctuates in the beginning of the business; thus, research examining the firm's evolutionary process in the macro-perspective, such as evolutionary economics, does not attend to the short-term phenomenon in terms of the firm's financial size, and this might lead to misrepresentation of the firm's performance. Therefore, research based on organization ecology considers the new firm's average survival period or employees' growth rate. The problem is that the number of the employees for new firms does not fluctuate significantly.

The firm's growth path passes the initial phase, the mature phase, and the decline phase. In the beginning, firms typically make efforts to acquire R&Cs prior to the growth preparation. As in the discussion of *de alio* and *de novo* market entrants, experiences prior to establishment make a difference in the R&Cs from the beginning (Helfat and Lieberman, 2002). Findings have shown that only 40% of the new firms survive for 6 years, and many firms are expelled in the beginning. It has been reported that 38% of the surviving firms do not show fluctuation in terms of the number of employees (Kirchhoff,

1994) and thus, in the beginning of the firm, because of the issues such as self-selection, it is not easy to show the statistical relationship between the firm’s roles and the firm’s growth with the data used in the theoretical perspectives of organization ecology and evolutionary economics. The firms entering the market make efforts to acquire R&Cs. In the course of mobilization and deployment, R&Cs are made ready to be extended and developed. When firms grow to a certain level, they can escape the risk of failing. The R&Cs become successful when they have mutual commitment with the market; however, this can cause problems when there are new products or services or changes in the market (Garnsey, 1998).

Firms develop R&Cs and acquire competitiveness through sufficient experiences and efforts. Firms’ learning processes include problem-solving routines, and firms extend their alliances with customers and distributors. The sales increase, and products and services are extended. The evolutionary economists emphasize that routines should be included among essential capabilities for the effective adaptation of firms to the industrial environment. This process starts at the very beginning of the firm’s initial period (Nelson, 1995).

For large firms, growth is explained using the conventional economic theory. It is reported that the firms need to grow until they reach the optimal size considering the efficiency in the industry, and the level of input capital is determined through the production function. In this context, the innovative technology and the organizational capabilities play the role of adjusting the level of input. Since the perspective of the economic theory looks into the firm's growth as a function of the size and the age in the equilibrium state, it has the limitation of not being able to interpret properly the effects of R&Cs that are unique to individual firms.

One of the phenomena discovered in terms of the firm's growth is growth reversal. The unexpected shortage of resources or capabilities, wrong decision-making, competitor's success, or the appearance of new products might cause growing firms to become stagnant or fall behind the competitors, and their growth stops or reverses. In the perspective of the organizational ecology, the niche strategy becomes useless due to abrupt environmental change, and the possibility of growth reversal increases. However, the problem-solving routine helps the recovery of the growth rate. The firms that have effective routines to solve problems with technological innovation will be able to solve technical problems, and the firms with the routines to acquire complementary assets through alliance will solve problems through alliance. When problems are solved, firms will gain reputation, orders for the products will increase, and so will the sales.

Growth reversal is a phenomenon that commonly occurs; however, is not seriously considered in growth theory. As for the growth reversal phenomenon, external effects such as industrial environment, appearance of competitors, and macro-economic shock have an influence; however, growth reversal becomes entrenched when there are no proper human resources or leadership to solve problems in the firms. To preempt the growth reversal phenomenon, it is necessary to have the capability to prepare for the future and to promptly overcome the risks, and these are embodied in decision-makers' capabilities inside the firms and are also the result of experiences and knowledge accumulated in the firms (Garnsey, 1998).

In empirical analysis on the firm's growth, it is not easy to consider the course of growth reversal. It is difficult to recognize growth reversal in the research on the firm's survival rate, because it is not easy to segment the change process during the growing process. However, if the firm's performance is divided into short-term and long-term and the growing pattern is analyzed dynamically, the growth reversal phenomenon can be discovered and its causes can be traced.

2.3 History and problems of firm growth models

2.3.1 The relationship between firm growth theory and models

The original firm growth model focused on the firm's size. Because it was thought that firms grow until they reach the optimal size, the firm's growth was discussed through the optimal size theory. This used a statistical framework and static analysis using size distribution and searched for the optimal size in the equilibrium state; therefore had limitations in interpreting the firm's short-term and long-term growth changes dynamically.

As the industrial environment becomes increasingly diverse and the uncertainty of the market increases, the issues of technological innovation and competition play an increasingly significant role in firm growth. This highlights the limitation of the neoclassical growth theory, which was the basis of the existing growth theory, and the endogenous growth theory was generated to overcome this limitation. The endogenous growth theory includes knowledge variables such as R&D or innovation as factors in the production along with the capital and the labor variables, and knowledge is considered as endogenous variables (as opposed to an exogenous variable). That is, knowledge contributes to total production, and the speed of knowledge accumulation is influenced by the size or the growth rate of the total production and the capital. Specifically, the speed of the knowledge accumulation is influenced by R&D investment, and as the experience and the size of the production increase, the learning effects increase the amount of knowledge. That is, as the total factor productivity (TFP) considering the effects of the technological innovation is included in the production function, the limitation of neo-classical growth theory is overcome.

Research into the path-dependency of the evolutionary economics has been conducted as another topic of the firm's growth. It maintains that firms have unique capabilities, and the organizations' routines play an important role in connecting the success of the past to the success of the future. It also explains the firm's growth with the theory that the firm-specific R&Cs are accumulated and become competitive advantage capabilities, and the firms thereby continue the long-term growth. Sometimes, poor routines result in structural inertia, which causes the opposite effects, restricting the firm's prompt adaptation to the environmental change, halting or reversing growth, and even resulting in firm failure. The firm's growth theory in terms of the evolutionary economy is different from the existing growth theories in that it focuses on the firm-specific routine as the cause to the growth as well as interpreting the growth theory not with labor and capital production functions but with the ability to adapt to environmental change and the firm's internal R&Cs.

In order to prove the rationality of the evolutionary growth theory through empirical analysis, it is essential to secure appropriate data and models that consider the firm's heterogeneity. In addition, the quantitative variables used to judge the firm's internal capabilities, including the routines, should be applied to the growth model. In addition, the relationship between these variables and the firm's growth should be explained meaningfully.

The development of firm growth theory is accompanied by the development of empirical analysis methods. Early (macroeconomic) empirical analysis could only see the average effect of the average firms. Therefore, it may have been easy to assess the firm's growth through the distribution of the size and the age, which are easily aggregated. However, the innovating firm's growth is essentially due to heterogeneous factors. Thus, it is necessary to reflect the firms' idiosyncratic talents, efforts, and routine in an accurate firm growth theory.

2.3.2 The measurement indicators for firm growth

The measurement indicators frequently used in firm growth research are the growth rates of sales, employment, and tangible asset. Currently, there are more industries in which firm growth is influenced by the intangible assets; thus, it would be logically problematic if the tangible assets alone represent a firm's growth rate.

As for employment, it does not require artificial deflation and is subject to fewer statistical errors or adjustments. Thus, it is used often considered along with the growth rate of sales. The growth rate of sales makes the best representation of the short/long-term changes, and is used most frequently as the growth indicator (Coad, 2009).

To measure the firm's growth, proportional growth is mainly used. Log-difference of size type is most popular, and its advantage is that the estimated result is not influenced by the heteroskedasticity. Its value comes out smaller than the % type, as demonstrated in Eq. (1):

$$g_{i,t} = \frac{S_{i,t} - S_{i,t-1}}{S_{t-1}} = \frac{S_{i,t}}{S_{i,t-1}} - 1, \quad \log(g_{i,t}) = \log(S_{i,t}) - \log(S_{i,t-1}) . \qquad \text{Eq. (1)}$$

Any indicators can be used to measure the firm's growth, and it is desirable for a researcher to select the right indicators by considering the industry for analysis and the research topic. Thus, growth theory has more interest in the variables explaining reasons for the growth rather than the growth measurement indicators.

2.3.3 Development of growth models

From neo-classical to endogenous growth

The neo-classical growth theory, which used to be the main growth theory, has various limitations. To overcome these, the endogenous growth theory was proposed.

The neo-classical growth theory argues that the causes of growth are exogenous technological progress and increases of labor power (Solow, 1956). When capital is accumulated, the marginal productivity is diminished. Romer's (1986) and Lucas Jr.'s (1988) first developed the endogenous growth theory in which the economic growth is considered using endogenous factors. The endogenous growth theory argues that technological advance is possible endogenously and human capital is recognized as the core variable for the endogenous growth; thus, more efforts are required to expand the human capital. This growth theory takes the theoretical approach of the macro economy and does not consider the individual firms' unique characteristics. Therefore, it also has a limitation to explain a specific firm's growth pattern.

Traditionally, the growth theory uses the production function model. The equation to analyze the firm's growth involves the estimation of the logarithmic transformation model using the conventional Cobb-Douglas production function. This is a conventional production function composed of the two production factors of capital and labor. The efficiency parameter conforming to A in Eq. (2) can have many interpretations; however, it is mainly understood as TFP. Excepting A, total production is composed of capital and labor functions. That is, the firm's growth is composed of the capital and the labor functions, which have high correlation with the size of the firm.

$$Y_{i,t} = AF(C_{i,t}, L_{i,t}) = AC_{i,t}^{\alpha} L_{i,t}^{\beta} . \qquad \text{Eq. (2)}$$

where Y is total production, C is capital stock, L is total labor, A is efficiency parameter, inferior letter i=1,2,… N is a firm, t=1,2,…., and T is time.

The firm's management performance can be measured by its financial statement. The factors that determine the firm's performance are productivity, profitability, efficiency, growth, and so on, and the indicators representing these factors are frequently used. Productivity is used as an indicator for management performance to represent the firm's external growth size (e.g., production per employee). Profitability is used as an indicator for management performance to represent the result of the firm's activity (e.g., ratio of operating profit to net sales, ratio of net income to net sales, etc.). Efficiency is used as an indicator to show how productive a firm's production method is (ratio of labor cost to the value added), and the estimation of TFP is accompanied. These factors can be the input indicators as well as the output indicators of the firm's performance excluding growth. Growth is an indicator to show how much the firm's management size, such as assets, capital, and so on, and activity performance increase year on year, and it is used as an indirect indicator to show the firm's competitiveness or profit-making capability in the future (e.g., sales growth rate, total asset growth rate, etc.). It is used as a representative output indicator.

TFP is an indicator to show the change of the production by the total input of the factors, unlike labor productivity or capital productivity, to represent the individual factors' productivity. As mentioned above, A in the Cobb-Douglas function means TFP. To estimate the TFP, an empirical model that has a natural log on both sides of the production function can be used, as in Eq. (3):

$$\ln Y_{i,t} = c + \alpha \ln C_{i,t} + \beta \ln L_{i,t} + \varepsilon_{i,t} \qquad \text{Eq. (3)}$$

where Y is total production, C is capital stock, L is total labor, c is constant term, inferior letter i=1,2,… N is a firm, t=1,2,…., and T is time.

The equation above categorizes the firm's growth into capital contribution, labor contribution, and Solow residual.[1] Solow residual refers to the influence on the firm's growth, which cannot be explained by the quantitative increase of capital accumulation or labor input. It can represent the individual firm's technological development or innovation. The indicator's value of the Solow residual is detected as TFP, representing technological progress.

As for the indicators of productivity, growth, and efficiency that can be used as dependent variables of the firm's management performance equation, it is expected intuitively that they might be heavily influenced by the firm's size and performance. In

[1] $\hat{c} + \hat{\varepsilon}_{i,t} = \ln A$

particular, the increase of the input of capital and labor is connected to the increase of the firm's size. Accordingly, the changes in productivity, growth, and efficiency can be observed; therefore, it is convenient to interpret the firm's growth as production function in the macro perspective, and for this reason it is still popularly used.

Gibrat's law

The most well-known law in the empirical analysis of the firm's growth is Gibrat's law.

If the firm's size is defined as x_t at time t and the random variable is ε_t to the individual firm from t-1 to t, then

$$x_t - x_{t-1} = \varepsilon_t x_{t-1} \qquad \text{Eq. (4)}$$

$$x_t = (1+\varepsilon_t)x_{t-1} = x_0(1+\varepsilon_1)(1+\varepsilon_2)...(1+\varepsilon_t)\text{, and} \qquad \text{Eq. (5)}$$

$$\log(x_t) \approx \log(x_o) + \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_t = \log(x_0) + \sum_{s=1}^{t} \varepsilon_s \text{ .} \qquad \text{Eq. (6)}$$

When t is big, the $\log(x_0)$ term is insignificant.

$$\log(x_t) \approx \sum_{s=1}^{t} \varepsilon_s \text{ .} \qquad \text{Eq. (7)}$$

That is, at time t, the firm's size is influenced only by the idiosyncratic history of multiplicative shocks.

In terms of the firm's growth, Gibrat's law uses the following form:

$$\log(x_t) = \alpha + \beta \log(x_{t-1}) + \varepsilon \,. \qquad \text{Eq. (8)}$$

Where x_t is the firm's size, α is the constant term (industry-wide growth trend), and ε is the residual error. If the firm's growth is irrelevant to its size, β has a unity value. When β is less than 1, it means that smaller firms grow faster than big firms; on the contrary, if it is bigger than 1, it means that bigger firms grow relatively faster. Much empirical research has reported that β is a little less than 1, which means that small firms tend to grow more rapidly than large firms.

Growth models after Gibrat's law and application examples

As an alternative to Gibrat's model in the firm's growth, Steindl (1965) suggested Pareto instead of lognormal distribution; however, this still emphasizes the stochastic models of growth. In particular, it excludes the analysis on small firms, and it is not useful in the analysis of the relations between the employment growth and the size of the company (Steindl, 1965).

Sutton (1997) developed a new stochastic firm growth model. He explained the firm's growth in the context of economic theories such as market behavior, game theory, and so on based on the manufacturing industry's industry level (Sutton, 1997). His model used two conditions. First, the probability of the next market opportunity generated by the currently active firm is the non-decreasing function of the firm's size. Second, the probability of this opportunity's continuity by the new entrant is constant according to time. It is a more general model than Gibrat's, since new firms are included in the model.

Geroski (1998) suggested six stylized facts of the firm's growth given his research results. The research was conducted on a sample of 280 big firms in the UK; thus, it hardly represents firms as a whole. However, the result shows that big firms grow more slowly than small firms. This research proves that, in terms of firm growth, there are no consistent results and trends (Geroski, 1998).

Evans (1987a) researched firm growth with 20,000 manufacturing firms in the U.S., and when measuring the firm's growth with employment, smaller firms grow faster than big firms, and it shows results consistent with those of Geroski's (1998) UK firms . However, the negative relationship between the size and the growth is strongly non-linear, and Gibrat's law of proportionate effect is not supported. Evans proves in the research on the firm's age and growth that younger and smaller firms grow faster and that there is a positive effect between age and size logarithms. Evans' research shows that age has a negative effect on growth, unlike in the learning by doing model.[2]

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[2] Evans' model can statistically verify Gibrat's law and Jovanovic's laws.

$$firm\_growth = \ln(S_{t'} / S_t) / (t' - t) = \ln G(A_t, S_t) + u_t \, ,$$

where S is the size of the firm measured by the number of the employees or the sales, t' is the last year of the sample, t is the first year of the sample, A is the firm's age from the establishment year to the first year of the sample, and u is an error term. The elasticity of the end-term firm's size to the initial firm's size and the elasticity of the end-term firm's size to the initial firm's age are defined as follows, where the partial differential of the growth function for the size and the age are defined as g_s, and g_a

Hall's (1987) research also measures firm growth with employment. It shows that smaller firms grow faster than big firms, and the research does not consider the firm's age, instead using capital expenditure and R&D investment logarithms for the variables. His research proved that these variables have a positive effect on firm growth.

It is known that the effect of age diminishes as time goes by. It is explained by the principle that because the technological progress is faster than the past, the importance of past experience decreases (Hart, 2000). These days, regardless of the age, the firms should adopt new technologies; thus, the accumulation from the previous output and experiences becomes obsolete more quickly.

2.3.4 **Criticism against the previous growth model**

As mentioned above, according to the neoclassical growth model, firms grow until the firm's size reaches the minimum average cost. There is no incentive for the growth beyond that point. This means that when the size reaches the equilibrium state it ceases to grow. This fails to explain the actual situation, where firms continue to expand through mergers and diversification. However, it can explain the small firms' fast growth compared to big firms' (up to the efficient size). Nevertheless, since small firms are subject to influence by various government's policies and are exposed to an imperfect

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$$E_s = \frac{\partial \ln(S_{t'})}{\partial \ln(S_t)} = 1 + dg_s, \quad E_a = \frac{\partial \ln(S_{t'})}{\partial \ln(A_t)} = 1 + dg_a, \quad (d = t' - t)$$,

and when d is normalized as 1, if it conforms to Gibrat's law, g_s=0 and, E_s=1. If it conforms to Jovanovic's law, it is g_a<0.

competition environment, which can affect the growth speed, the neo-classical theory alone cannot explain the true situation.

The firm's growth is determined not only by cost but by price, credit condition, product's diversity, quality, service, and demand of a specific product. Thus, the firm's growth in the diversely imperfect competitive situation is not captured by the neo-classical theory.

Though the endogenous growth theory adopted the knowledge capital as a drive for the growth to the model and thereby overcame many limitations of the growth theory, it does not reflect the actual activities of the individual firms on the measurement of TFP.

The following example is the interpretation of the growth rate[3] of TFP. In the assumed production function, TFP is defined as the rest excluding the contribution of two input factors (labor and capital) to the production, and the elasticity method is shown as follows for the total factor productivity growth rate (TFPG), which is defined by Eq. (9):

$$TFPG_i \equiv \frac{\dot{Y}_i}{Y_i} - \hat{\alpha}_i \frac{\dot{L}_i}{L_i} - (1-\hat{\alpha}_i)\frac{\dot{C}_i}{C_i} = \lambda_i + \gamma_i \frac{\dot{K}_i}{K_i} + u_i . \qquad \text{Eq. (9)}$$

Where the total of the factor compensation share for the input factor is assumed to be 1, Y = yield, L = labor, C = capital, K = knowledge stock, t = time, and u = error term. The variable with a period (.) means the increased share for the time and thus, each

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3 Suh (2005)'s writing form was used.

variable term is marked as growth rate.

Since the parameter γ_i conforms to yield elasticity (= $\frac{\partial Y}{\partial K}\frac{K}{Y} = \rho \cdot \frac{K}{Y}$),

$$TFPG_i = \lambda_i + \rho_i \frac{\dot{K}_i}{Y_i} + u_i \,. \qquad \text{Eq. (10)}$$

Thus, Eq. (9) can be converted to Eq. (10), and ρ is the conventional return rate of the knowledge stock. Ultimately, for both yield elasticity and return rate, the calculation of knowledge stock is an important factor. The accumulation of the knowledge stock is determined by depreciation rates (obsolescence rates), R&D investment, and other factors and the calculation result of the knowledge stock is influenced by the depreciation rates (obsolescence rates) (Hall and Mairesse, 1995). In particular, in the estimation of elasticity, the knowledge stock (K/Y) against the yield is influenced by R&D intensity, which is the calculation of R&D investment against the sales by using the actually observable R&D investment.

After all, the TFP contributing to the rest of the production excluding the two direct input factors is influenced by the R&D intensity, which is also influenced by the firm's size (i.e. the sales). Thus, it is clear that R&D intensity is the factor influencing the firm's performance, like the labor and capital that have direct influences on the firm's size; however, it does not represent the individual firm's unique activities.

TFP increase can be achieved through the technology innovation, as described above.

Since TFP is the production efficiency that reflects not only labor productivity but worker's work capability, capital investment amount, technology level, and so on, it reflects technology, labor and management, management system, law, and system, which are not included in the measurement of single factor – such as labor, capital and so on – productivity. However, even in the case of TFP representing the individual firm's technological development or innovation, because the focus is not on the individual firm's activity but on the firm's size or age, it is predicted that TFP increases as the size increases.

In addition, it has weak points given that the meaning of technological innovation is not specific and collecting quantitative data from individual firms is not easy. The empirical analyses on the effects other than the size and the age in the firm's performance have been conducted restrictively so far due to the data issue and the limitation of the analysis model.

Klette's model[4] shows that the performance indicator of the TFP explains the characteristics of the R&D investment (Klette, 1996).

Klette's (1996) model can be used for prediction according to the characteristics of the R&D investment and substitutes the knowledge stock (Klette & Johansen, 1998). The performance indicator in Klette's model conforms to the TFP in the production function and is defined by Eq. (11):

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[4] Suh (2005)'s writing form was used.

$$\hat{a}_{it} = (\rho - \nu)\hat{a}_{it-1} + \gamma\nu\hat{r}_{it-1} + \lambda_1\hat{i}_{it-1} + \lambda_2\hat{x}^C_{it-1} + \hat{e}_{it} . \qquad \text{Eq. (11)}$$

where all the variables are defined as the ratio between reference firm and individual firm, $\hat{a}_{it}$ is the individual firm's performance indicator, $\hat{r}_{it-1}$ is the R&D investment for the entire period, $\hat{i}_{it-1}$ is the facility investment rate against the capital stock for the entire period, $\hat{x}^C_{it-1}$ is the capital stock for the entire period, and ν is the innovative parameter for the firm's growth (the effect to increase the sales through the product innovation and process innovation by the knowledge stock [marginal product of knowledge with respect to sales]) (Klette, 1996; Klette and Johansen, 1998).

Klette's (1996) model also has limitation. As for the representation of the causal relation between productivity and R&D investment, it has a spurious correlation (Suh, 2005). That is, R&D can enhance the productivity; however, since the firms with higher productivity make more profits and are able to have more R&D investment, this spurious correlation occurs. There is no way to solve this problem perfectly (Stoneman, 1995). Efforts can be made with a method of setting some time-lag for the R&D investment or a method of assuming multiple causal relations by setting simultaneous equations with acquiring over variables. R&D intensity is generally considered to be independent of the firm's size, and is thus used instead of R&D investment (Suh, 2005). However, to see the firm's growth considering individual firm's characteristics, it is still necessary to develop a variable to show the unobserved heterogeneity of the firms other than R&D intensity.

For example, it should be a variable that is independent of the firm's size or age but still reflects the firm's characteristics and clarifies multi-causal relations.

Firms increase the assets, invest in R&D, and supplement employees in order to generate performances and contribute to growth. So far, the return rate of R&D investment has had a big effect on productivity; thus, the R&D effects were significantly considered in the performance indicator of the production function, and it became a stylized fact that R&D investment observes Gibrat's law, which follows the random walk (Klette and Griliches, 2000).

The point to be careful about R&D investment for the firm's growth is to separate the productivity effect of R&D investment and the productivity of R&D investment itself. That is, firms with more R&D investment have higher productivity, though the correlation between R&D investment and the increase of productivity is not high (Suh, 2005). In particular, the activities for the firm's performance should contribute not only to the short-term performance but also to the long-term performance (i.e., continuously).

It is true that the process to verify the effects of technological innovation by introducing TFP to the production function facilitated the studies on the roles of R&D activities in the production process or in the economic growth process. However, there is a limitation of the model in that the theoretical prediction of the model used in the empirical analysis does not conform to the firm's performance. There has been extensive research on the effect of firm's activities on firm growth; however, difficulty in collecting appropriate data has been an obstacle to detailed research. It is necessary to secure data representing the unobserved heterogeneity of firms and, more importantly, to compose the theoretical prediction of the model more realistically where firms' idiosyncratic variables are used in the empirical analysis. Therefore, securing the right data is important, though the more important task is to conduct a strictly empirical analysis with a realistic theoretical model.

2.3.5 Evolutionary growth theory

Nelson and Winter (1982) proposed evolutionary theory in the discussion of the firm growth. They explained that firms use routines reflecting the idiosyncratic firm instead of the optimization in the market and tend to adapt themselves automatically to the change of the market. They maintained that the know-how that firm's members build from their experiences and skills are passed on to the firm's new members, and, thus, the past's routine makes an impact on the future. When there are environmental changes, successful firms change their routines to fit the new environment.

Measuring success is possible by measuring the labor productivity and so on, and firms with high productivity are known to maintain that level of productivity for 2–4 years (Oulton, 1998). It is true that some types of firms with good routines infrequently fail. However, the general perspective of evolutionary economics (maintaining that success leads to further success and failure leads to further failure) clearly contradicts the pure stochastic models of growth that argue that the growth rate of the surviving firms is determined randomly regardless of the previous success, as with Gibrat's law of proportionate effect (Hart, 2000).

The dynamic models of entry and exit for the evolutionary growth model were developed by Brock (1972) and Smith (1974). In this model type, it is assumed that the firms have the same size. The equilibrium model does not include firm-specific stochastic elements that cause firm's dynamics, and this issue was first discussed by Jovanovic (1982). Pakes and Ericson (1989) developed the implication of the learning model and suggested the idea that a firm's production is influenced by uncertain performance as well as investment.

The two models of Jovanovic (1982) and Pakes and Ericson (1989) provide many implications for the firm-level dynamics (Hopenhayn, 1992). The learning model explains the firm's evolution with the firm's size distribution according to age. The majority of related research has been on the firm's growth judged by the survival rate.

The firm's size measured by input or output is explained by the increase function related to productivity. Hopenhayn (1992) explains theoretically that the older, bigger, and more profitable the firms are, the higher the survival rates are. Hopenhayn (1992) explains the entry and exit in terms of entrants' change of distribution. Learning models can be divided into passive learning and active learning, described in the following two subsections.

Passive learning growth theory

The passive learning model uses a Bayesian model to explain that efficient firms grow and survive and inefficient firms decline. In particular, Jovanovic's (1982) passive learning deals with small industries with homogeneous products, where the time path of the demand for the product is determined and known. In addition, the factors are given at the same price. In this competitive environment, firms are assigned uncertain and time-invariant characteristics in the beginning. Each firm should make a decision on the strategy in each period. That is, firms should decide whether they exit, maintain size, increase size, or reduce size. Since this model specifically follows the selection process, the most efficient firms survive and grow, and less efficient firms are stuck in the market or leave the market. Since it assumes small industry size and product homogeneity, it cannot seek niche strategies with the characteristics of different paths from lognormal distribution. If new firms in the suboptimal scale find the true cost to be low, they expedite the growth and adjust their size as fast as they can. In this model, as time goes by, the size distribution of the survival firms is stochastically interesting.

Active learning growth theory

Ericson and Pakes' (1995) active learning assumes that all decisions that firms make are intended to maximize the discounted value of the predicted future net cash flow under the condition of the current information set, as in the passive learning model (Ericson and Pakes, 1995). However, the active learning model assumes that firms know all about their characteristics and those of competitors under the current structural condition according to the future distribution of the industry structure. The Jovanovic model's assumptions of small industry size and product homogeneity are alleviated in Ericson and Pakes' model. The new entries adjust their sizes to the industry core output's minimum efficient scale (MES) level. If the firms do not grow fast, they identify niches to increase their survival probability. In the active learning model, more firms in all industries can enter the market (for all periods) than the market can hold. Pakes and Ericson (1998) reported that the retail industry and the manufacturing industry follow the passive learning model and the active learning model, respectively. The retail cohort revealed that it followed the size distribution of the entire industry over eight years, while the manufacturing cohort revealed that, though it achieved a high growth rate, it still had a discrepancy from the size distribution of the entire industry after the same period of years. The cause to the discrepancy is that the manufacturing aggregate is less homogeneous compared to the retailing aggregate.

Other evolutionary theories

Audretsch (1995) expanded Jovanovic's (1982) theoretical research from the evolutionary perspective. It emphasized the inter-industry difference of the survival possibilities of new firms. Audretsch (1995) argues that both new firms/start-ups and large incumbent firms contribute to the economic development, although not in all industries. To explain the industry heterogeneity in relation to the new entrant's evolution of the size distribution, Audretsch (1995) separates the routinized regime from the opposite entrepreneurial regime to see if it is favorable to the innovative entry or less favorable to the existing firm's innovative activity. As a result, according to "growth regimes," it is maintained that in some industries, small firms have the innovative advantages and have the entrepreneurial regime, while in other industries, large enterprises have the innovative advantages and have routinized regimes (Audretsch and Fritsch, 2002). It is argued that this type of size economy and the industry-specific characteristics, such as endowment of the innovative capabilities, make a meaningful influence on the new firm's entry, exit, and survival possibility.

For example, in the industry with the characteristics of a high MES level, the smaller firms have higher costs, and thus they have a higher likelihood to be expelled from the market within a short period of time in the beginning. Therefore, the most efficient new firms survive and grow, while the rests are exposed to the risk of being expelled from the market. In this case, the appearance of firms with higher potential than the firms with the long-term survival possibility can cause shakeout (Klepper and Miller, 1995). The shakeout occurring at a certain time can influence the firm's long-run size distribution within the same industry.

On the other hand, in an industry with a low MES level, the firm's survival possibility is not related to growth capability. This perspective implies that the industry- and firm-specific factors influence the firm size's convergence of lognormal distribution; in industries where smaller entrants have the innovative advantage, the convergence speed will be faster, and in industries where the existing firms have the innovative advantages, the convergence speed will be slower.

A population of firms cannot represent the optimized individual firms. Instead, the significant heterogeneity of firms is recognized. Therefore, the firms with high productivity co-exist with the firms with low productivity in the same industry. However, not all firms belonging to the same industry grow or diminish. Resources are assigned to more productive firms and the less productive firms are expelled. The evolutionary theory follows the bounded rationality, and the firm's future cannot be predicted based on the rationality. Depending on the involvement of luck or will, the firm's future can be changed. As a result, firms cannot decide the investment by deriving the future value from the current value. Instead, the investment is determined by the current financial performance. The mechanism of the evolutionary theory is "selection via differential growth." It follows Fisher's fundamental equation[5]:

$$\delta x_i = \alpha x_i (F_i - \bar{F}) . \qquad \text{Eq. (12)}$$

where δ means infinitesimal interval $(t, t+\delta t)$, and x_i represents firm i's market share. F_i is the 'fitness' of the target firm for consideration and is measured in the same level with the financial performance or relative productivity. $\bar{F}$ refers to the population's average fitness. There are not many empirical analytical studies concerning this. It is known that return rate and productivity rate are independent of the firm's growth (Coad,

[5] Coad (2009)'s writing form was used.

2007) and that financial performance is not a factor determining firm's growth (Coad, 2009).

Fitness means that profitability and productivity are good. However, its empirical analysis is not conclusive. The general conclusion is that, in reality, the sales growth is independent of profitability. Therefore, the fitness plays a clear role as an indicator of profitability and productivity, though product quality or cost level may seem to play the role of indicators (Coad, 2009).

The niche strategy, which is the representative characteristics of the population ecology, does not consider the firm-specific factors and is applicable to all organizations; however, it cannot be controlled by firms. Thus, it is not very helpful in terms of firm's strategy. In particular, because "niche" refers to a specific industry (e.g. automobile industry, bio industry, etc.), it is necessary to have the life-history data for the population. Therefore, the main interest is in investigating the organizations' birth rate and death rate and seeing the effects of the population and environment on the organizations' performance.

Neoclassical literature states that firms invest as long as it is perfectly rational and can increase the firm's long-term performance; however, the imperfectness of the actual financial system causes problems. On the contrary, evolutionary economics rules out the excessive rationality and maintains that firms are heterogeneous and have limited rationality and, therefore, that not all firms grow.

It is known that productivity has little correlation with firm growth. Some firms with high productivity reduce their size, and other firms with high productivity increase their size. It has been reported that many empirical studies have met with difficulties in revealing the relation between productivity and firm growth (Bartelsman and Doms, 2000; Bottazzi et al., 2008).

2.3.6 Criticism of evolutionary growth theory

The efforts to consider the firm's characteristics and to discuss the firm's growth beyond its scale are called "learning by doing." As for the initial learning by doing, the learning curve is generalized as the Boston Consulting Group's experience curve. The basic idea is that the production average price is not so much dependent on firm's output size as it is reducing logarithmically according to the firm's past output accumulation. The learning by doing concept received interest from business management and economists; however, it has a limitation in explaining the firm's growth model. That is, relatively small firms have less accumulated output, and thus, big firms are always in the more favorable position. Because bigger firms follow the learning curve more faithfully, they are always more likely to grow. In addition, it reaches the invalid logic that if the sizes of the firms are the same, the accumulated outputs by learning by doing are the same. Therefore, it is necessary to develop a proxy variable to measure the R&Cs accumulated through the learning by doing instead of the firm's size or age.

The model of the evolution of industry suggested by Jovanovic (1982) conforms also to stochastic growth. In his model, individual firms' cost curves are randomly distributed and are subject to firm-specific shocks. The firms experiencing favorable shocks grow, and those that do not diminish or fail. Jovanovic's model shows that the smaller firms have higher growth/failure rates at the same time compared to those of the bigger firms. If his theory is correct, because the expelled firms are excluded from the target in the empirical analysis, it is likely that the relatively small firms' growth rate is overestimated. Thus, it may be difficult to explain the firm's evolution accurately.

Evolutionary theories argue that the successful firm's growth continues over time. That is, the growth in the consecutive periods has the positive serial correlation, and the older firms grow faster than the younger firms because older firms have more accumulated performance and more opportunities for learning and experience. However, the actual empirical analysis shows the opposite result from this. Hart and Oulton (1998) reported that there is a negative relationship between age and the growth of the surviving firms. Such a negative effect of age on growth does not match with the learning by doing model.

2.4 Implications

The firm's growth theory has been reviewed, from classical production function to the endogenous growth, the evolutionary economics theory, and active/passive learning models. Various causes and results in relation to the firm's growth have introduced through many empirical analyses. The following issues are generally recognized in relation to firm growth.

Firm growth has a close relationship with survival (Evans, 1987b; Hall, 1987). There is a positive correlation between a firm's growth and its survival rate, meaning that the firms with continuous growth have a higher likelihood of survival. Moreover, a firm's growth causes increase in employment. In other words, a firm's growth can be explained by the newly created employment, which is newly created or disappeared during a certain period of time. In addition, the firm's growth increases innovative capability and supports the technological change (Pagano and Schivardi, 2003). Firms need to develop new or more efficient technology to survive in the intensively competitive environment. Thus, it is important for the firm to seek growth through innovative activities. In addition, it is known that more efficient firms grow faster, which also increases the size of the firm. On the other hand, this means that the less efficient firms reduce in size and may exit from the market. The endogenous growth theory offers a good explanation of this phenomenon.

Recent research shows that there is a negative correlation between the size of the initial firm and the post-entry rate of growth in terms of the firm's growth. As for the new firms, growth rate has a negative correlation with initial sizes only during their infancy (Lotti et al., 2001). Recent research also proves that Gibrat's law is not valid because the firm should reach a certain size in order to have a higher survival chance. However, it also explains that, the growth pattern of the entrants is not so different from that of the entire industry after a certain period of time.

The common factor of the stylized fact is to explain the firm's growth with its size or age effect rather than firm's activities, such as experiences or efforts. This is because of the following two characteristics. First, the unobserved heterogeneity value, such as experience or effort, in the growth model cannot be discussed sufficiently due to the difficulty of collecting data. Therefore, the firm's growth has been explained through the values that have been known for decades, such as the size and age of the firm. Those values are also easy to collect. Second, the firm's particular efforts or routines are not sufficiently reflected in the knowledge stock.

The resources and capabilities should be considered for the firm's unobserved heterogeneity

The existing theories and empirical analyses on the firm's growth focus on the firm's size, age, and innovative activity. Even though the organizational ecology or the evolutionary economics argue that firm's growth and survival are influenced by the individual firm's R&Cs, only the firm's size, age, or R&D investment are used to study firm growth. A firm's R&Cs are accumulated from the experiences and the efforts through learning by doing. The reason that the firm's R&Cs are not counted in the empirical analysis of the firm's growth is that it is difficult to collect data on individual firms' specific activities. Another reason is that the measurable data are objectively limited to the firm's sales, asset size, the number of employees, the number of patents, or R&D investment cost, and so on.

Understanding the firm's growth recognized macroscopically can be beneficial to policy-makers who seek to increase the efficiency and the influence of the public policy. However, it is not so beneficial to managers, who seek to increase their firm's actual growth rate and strengthen its competitiveness. This is because the size and the age cannot reflect the generation/evolution processes of the individual firm's unique R&Cs. In addition, they are not variables that the firm's manager can control.

In particular, it is more difficult to collect data on smaller and younger firms. As for the new firms, since their history is short and the fluctuation of financial performance is relatively larger than that of pre-existing firms, it is not easy to measure the firm's growth by the size, age and financial performance data. The newly established firm's growth is, rather, influenced by the type of R&Cs inherited from its parent firm or the degree of its experience and efforts to adapt in its new environment.

The individual firm's unique experience, efforts, and routine should be reflected in the growth model.

A firm's internal capabilities cannot be understood by its external scale of size. The R&Cs or the knowledge stock that the firm owns can explain the current level of the firm; however, these factors are not sufficient to determine whether the speed of the firm's growth will be increased or decreased in the future. The firms with high learning capabilities can generate higher productivity and efficiency, even if it they the same experiences and efforts as their counterparts. In addition, depending on the type of routines, the firm's desired direction for growth varies.

To apply these ideas to growth theory, the knowledge stock in the endogenous growth theory should be extended to the concept including the efforts and routine. The firm's effort to obtain capabilities and distinctive routines can produce different growth rates, although it is true that the stock of distinctive resources can also influence the firm's growth rate.

To make a clear measurement of the individual firm's differentiated capability and growth efforts, it is necessary to obtain relevant data. Furthermore, to achieve accurate estimation of the relationship between the firm's growth and the firm's characteristics (specifically on its capability and growth efforts), the current growth theory and growth models should be improved. To fully understand the firm's growth, it is important to detect the firm's internal/external characteristics.

Therefore, the criticism of the existing growth models as the function of production and firm size has been discussed, and the alternative idea has been suggested. In the present research, the impact on firm's growth is analyzed by assuming that the unobserved heterogeneity, such as R&Cs, is produced and developed through pre-entry experiences and post-entry efforts. Specifically, this research assumes that the type of a firm's initial post-entry efforts effects would cause differences between short-term performance and long-term performance. This research also analyses whether the firm's post-entry effort can create routines and whether these routines can influence future performance.

Chapter 3. Literature Review of Resources and Capabilities

3.1 Basic concept of theoretical perspectives

"Resources" are generally categorized as tangible assets and intangible assets. Examples of tangible assets include financial resources, capital equipment, buildings, land, and so on. Intangible assets include corporate culture, routines, technical capital (e.g. patents), reputation, brands, employee loyalty, networks, and so on. One of the most comprehensive definitions is proposed by Barney (1991), who defines resources as all assets, capabilities, organizational processes, firm attributes, information, and knowledge, among other elements, controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness. While resources are stocks of available factors that a firm owns or controls, including both physical and human assets, "capabilities" are the processes by which firms control resources when attempting to achieve desired results (Amit and Schoemaker, 1993).

An understanding of firm growth and how to optimally use R&Cs to that end has been a central theme in economic theory. However, the treatment of R&Cs in economic theory has, at times, been problematic. For example, in general equilibrium theory (the neo-classical microeconomic theory), it is posited that R&Cs are homogeneous, information is perfectly available and evenly distributed, profit maximization the central goal, and an equilibrium level of output guides production decisions. Clearly, general equilibrium theory was deficient in that it failed to properly consider the internal operations of firms. For these reasons, there were several early and notable attempts to break away from the general equilibrium model (Darroch, 2005).

Firm-specific R&Cs derived from different experiences and efforts clearly have a strong influence on a firm’s growths. Thus, the present research aims to examine the effects of the innate/acquired R&Cs on the growth of new firms from the perspective of nature/nurture, respectively. The core theories used to explain this are organization ecology and evolutionary economics. The resource-based view combines these two theories and connects the R&Cs to the growth of firms (Fortune and Mitchell, 2012). Thus, these three theoretical elements are reviewed in the present chapter.

Table 1. Descriptions of resources and capabilites

	Description
R&Cs	· Not limited to buildings or cash but including the creation of new value with the effective combination of management resources that firms have (Penrose, 1959) · Divided into three broad categories: Physical and human and organizational (Barney, 1991)
Resources vs. Capabilities	· Subsequent research has distinguished resources from capabilities in more detail (Amit & Schoemaker, 1993) – Resources are assets that are either owned or controlled by a firm – Capabilities refer to a firm′s ability to exploit and combine resources, through organizational routines, in order to accomplish its targets.
Pre-entry R&Cs	· General sorts of R&Cs along two dimensions in analysis of market entry (Helfat & Lieberman, 2002): – Core vs. complementary R&Cs – Specialized vs. generalized R&Cs

3.1.1 Organization ecology perspective on pre-entry resources and capabilities

Organization ecology was proposed in the late 1970s by Hannan and Freeman. The firms in a single industry are viewed as one "population" of organizations, and the theory explains the diversity and variation of the interactions within a population. Therefore, organization ecology is not intended to examine information on concerning individual organizations; rather, it collects the information on all the organizations within a population, and thereby removes the selection bias in order to consider the diversity of the population.

Organization ecology emphasizes how the environment selects organizations for growth rather than how organizations adapt to the environment (Hannan and Carroll, 1992). This logic is the same as in biological evolutionary theory in that only the firms that are well adapted to the new environment can survive. Organization ecology posits that certain organizations are doomed by the environment to fail due to their structural inertia (Hannan and Freeman, 1989). The organizations' inertia prevents organizations from being equipped with the flexible strategies and structures necessary to fit to the new environment and thus, organizations customized to the previous environment decline, while those with strategies and structures appropriate to the new environment newly thrive (Carroll and Hannan, 2000). This perspective considers the changes in the organizational generations in terms of preferential selection rather than innovation.

In the case of new firms, structural inertia comes from pre-entry experience. The pre-entry experience contributes to the creation of the inherited R&Cs. When the inherited R&Cs of new firms are well-suited to the existing environment, the survival rate of these firm increases, and these structural inertias affect the future growth of firms. Thus, the organization ecology perspective provides a useful theoretical background for understanding the effect of the pre-entry experience on firm growth.

New firms tend to be influenced initially by the environment because of the liability of newness (Freeman et al., 1983). To be selected for success by the environment when established, the firms need to overcome this liability. To do so, it is essential to understand the environment of the market and the population at the firm's inception. To understand the effects of the population, it is necessary to look into the effects of the population density on the firms' survival. In dense populations, the competition would be fierce and firms would be eliminated easily (Carroll and Hannan, 2000; Hannan and Carroll, 1992). Conversely, low density means less competition; thus, firms entering the market at this time have a high rate of survival. If entering a market with high density, new firms have lesser networks than established firms, and it is difficult for them to achieve a significant market share (Barnett, 2008; Baum and Ingram, 1998; Carroll and Hannan, 2000).

Organization ecology focuses on the research on the population rather than on individual firms. The main argument is that the characteristics of the environment determines the survival of the firm. Therefore, the relevant empirical research is mostly concerned with the formation of firms (Carroll and Khessina, 2005; Delacroix and Carroll, 1983; Kuilman and Li, 2006) or the mortality process of organizations (Carroll, 1983; Carroll and Delacroix, 1982; Freeman et al., 1983; Hannan and Carroll, 1992; Hannan and Freeman, 1989).

In addition, organization ecology considers size and age as important factors for the growth and survival of firms (Ranger-Moore, 1997). Liability of newness (Freeman et al., 1983) and liability of adolescence theory (Fichman and Levinthal, 1991) attracted attentions because how new firms' handicaps in terms of size and age affect the mortality rate of firms was of central interest within organization ecology.

Recently, Oertel and Walgenbach (2012) have criticized the existing organization ecology research for focusing on large organizations, emphasizing the small/medium-sized firms and considering governance structure of organizations, population density, and legitimacy as the crucial success factors for organizations (Simon and Peter, 2009). In addition, organization ecology examines the effects of the partner's elimination on the mortality of the organization (Oertel and Walgenbach, 2012) as well as the effects of the early state of new firms on the population density and the growing process of the new organizations (Carroll and Hannan, 2000). The concepts of density and legitimacy are usually measured as correlated with the population density item (Carroll and Hannan, 2000; Hannan and Carroll, 1992). When organizations lack legitimacy, the proper licenses, capital, and qualified employees cannot be secured, and the survival rate declines (Sine et al., 2007). New organizations are considered to have low liability of newness because of the lack of trust and legitimacy, and it is believed that the legitimacy increases when the reputation and network are improved. Since organization ecology posits that structural inertia prevents adaptation, the selection of new firms by the environment in the beginning depends on the R&Cs that the new firms have when they enter the market. Therefore, organization ecology provides an important theoretical background for understanding the effects of inherited R&Cs.

As time passes, the issue of adapting to the environment becomes more crucial than that of being selected by the environment, as firms characteristics develop. Thus, the organization ecology perspective of interpreting firms' dynamic patterns solely in terms of age and size has its limits. Depending on the firms' states, the effects of the population density can be different. For example, a high density of big firms does not have any impacts on small firms. This is because big firms do not see the small firms as their competitors. Conversely, a high density of small firms can be no threat to big firms. As shown before, in the situation where not all the firms have the same states, the influence of the environment lessens, and firms grow and adapt to the environment, it would be more fruitful to examine the growth of firms from the perspective of evolutionary economics.

3.1.2 Evolutionary economics perspective on post-entry resources and capabilities

Evolutionary economics considers R&Cs in a more dynamic way. It considers the heterogeneity of the firm and how it develops through time, and thus it is effective for studying nurtured R&Cs.

Nelson and Winter (1982), the representative scholars of evolutionary theory, introduced the concept of ‘routine’ as the underlying organization of a firm, thus being analogous to human genes. In terms of the introduction of the firms’ innovative activities into the perspective; however, the interpretation of the firms’ innovation and R&D activities as analogous to biological variations is a new perspective. While explaining the firm’s economic phenomenon by using the biological mechanism, Nelson and Winter (1982) consider that firms retain a knowledge base and that this is path dependent. The knowledge base can be explained by the concept of routine, and through this routine, the firms' capabilities are explained, and through decision-making process, the growth of firms is explained. Thus, their approach is meaningful to view the interaction between firms and environment in a dynamic perspective. A new firm's pre-entry experience is the start of this interaction, and the experience after this – that is, post-entry effort – is when the nurturing of R&Cs starts.

Evolutionary economics sees that firms produce their output through their complicated production routines, including their specialized resources accumulated over a long period. This becomes their competitive advantage and a factor determining their future strategy's path (Dosi, 2000). New firms' post-entry effort can become the most important aspect of the initial stage, newly forming the routines. If this this secures their competitive advantage, the newly nurtured R&Cs as well as their inherited R&Cs will positively affect the future performance of firms.

The phenomenon that evolutionary economics focuses on is the process when the new firm or new routine is created. This can be referred to as variation, and in the situation where firms are not satisfied with the present status and do not have complete rationality, firms seeking future development seems a logical strategy. This process of searching for new development is explained with the intensive search and extensive search by Levinthal and March (1981). This explains firms' state well as a basis for how to grow the existing businesses and how to secure new growing force. March's argument also focuses on the R&Cs and the utilization of the core capabilities, similarly to the theories explained before. In local exploitation, to increase the short-term effects, firms utilize their R&Cs in the areas that firms do well in, and the evolutionary process remains bound by this strategy. To go to the new area. as in the case of entirely extensive exploration, innovative efforts are necessary, requiring appropriate R&Cs.

As for the new firms, if the decision of whether to focus on local exploitation or extensive exploration in the process of making the initial new routine affects the firms' long-term growth as well as short-term growth, it should be a significant consideration in management strategies. If research on the firms' post-entry effort or the situation of the nurtured R&Cs will tell whether the firm is stability-oriented or challenge-oriented, and also if these activities affect long-term performances as well as short-term performances, it can demonstrate that firms' initial experiences create the nurtured R&Cs and that these continue to develop and affect the long-term growth. This will contribute to the elaboration of the evolutionary economics theory. Since the individual nurtured R&Cs due to the post-entry effort differ between firms, the resource-based view on the R&Cs should be understood in terms of the idiosyncratic firm-level (Fortune and Mitchell, 2012).

3.1.3 The resources-based view on pre-entry and post-entry resources and capabilities

The resources-based view in relation to the firm's performance can be compared to the industry organization theory. Firms' performances have been discussed with the concept of distinctive competence (Selznick, 1957). The SWOT analysis that firms continue to use was defined by Andrews (1971): the strengths and weaknesses of firms are defined by how firms respond to the opportunities and threats from the environments around the firms. This insight prompted research into firms’ differences in performances based on the separation of the external environment and firms’ internal competence.

This trend directed the interest toward the industrial environment rather than the firms’ internal competence in the 1980s with the industrial structural analysis method, explaining the firms’ performance through the analysis method derived from industrial organization theory and empirical research. However, industrial organization theory is limited. It cannot provide the answer to the question of the differences in firms’ performances when each firm analyzes the industry precisely, sets and executes the proper strategies, and accumulates the necessary R&Cs. The reason is that industrial organization theory analyzes what firms enter the market promptly with the precise judgment and how suitable firms’ structures are for the applicable industry; thus, it does not explain the differences of the performances made in the same condition. That is, the industrial organization theory has the assumption that all firms are fundamentally the same based on the competition strategy theory. However, the resource-based view is the opposite to this approach.

The resource-based view was used first by Penrose in 1959, and after Wernerfelt (1984) introduced it in the strategic management area, it developed very fast in the late 1980s. Contrasting from the industrial organization theory, which judges the industry’s attractiveness, the resource-based view provides an answer to the question of which individual firms are likely to succeed in the industry. In the process of selecting the right industry for the firm, the resource-based view emphasizes the analysis of the firm's internal R&Cs rather than the external environment. Therefore, the important factors for firms' performances are selecting the right industry to enter (i.e., that where the firm can make use the best of its R&Cs and to continue to secure more R&Cs than other firms in the industry). It is meaningful to consider the connection between selection and adaptation from the perspectives of organization ecology and evolutionary economics applied to R&Cs.

The R&Cs that Penrose (1959) mentioned are not limited to buildings or cash but include the creation of new value with the effective combination of available management resources. They also include new values, such as experience and learning, that can be created through the interactions between existent R&Cs in the firms. That is, R&Cs can be combined with other productive factors in the firm to create experience and learning that assists with the growth of firms. This emphasizes the importance of nurtured R&Cs. Since Hamel and Prahalad (1990) used the concept of core competence in the late 1990s, the recognized scope of R&Cs has extended, and 20 years later it is still widely used in the firm's for setting management strategies.

Either in the analysis of the firms' strength and weakness in Andrews' SWOT analysis or in the selection of a preferable industry fit to the firm's competitiveness in the industrial organization theory, the firm's R&Cs takes precedence. In addition, for the continuous growth of the firms, it should be carefully observed how pre-existing R&Cs develops or declines through time. The problem is that it is not easy to measure and judge R&Cs: markets are uncertain, and firms' R&Cs are complex and diverse.

Barney (1986) states that the uncertainty of the productive component market highlights competitive advantage and that if the R&Cs that create the competitive advantages, such as technology and brand, can be purchased easily in the component market, such competitive advantages will disappear easily (Barney, 1986). Therefore, it was emphasized that to create the sustainable competitive advantages, the R&Cs to make the competitive advantages should not be easily secured or copied. Dierickx and Cool (1989) state that the fundamental reason why the R&Cs are difficult to copy lies in the accumulation process of individual R&Cs, which helps to understand the concept of experience or learning (Dierickx and Cool, 1989). Their argument prompts the use of knowledge-based resource and organizational learning in explaining R&Cs. Grant (1991) states that learning through many repetitions is required for R&Cs to become core competences. The core competences used widely in similar industries are the accumulated knowledge, learning, and experience in the firm. Teece et al. (1997), on the basis that a firm’s core competence is created through the long interactions between the firm’s R&Cs, conducted a research on how these R&Cs are accumulated.

R&Cs are divided into physical resources and human resources (Penrose, 1959), and the human resources, compared to physical resources such as buildings, machines, or cash, can be more easily combined with other resources and create new knowledge or experience and play more important roles in the growth of the firm. In particular, human resources are very important because they are intangible resources and, at the same time, through experience and learning, become the main agent to produce other R&Cs. In the late 1990s, the emphasis was placed on the intangible (or knowledge) resources among R&Cs, because the physical resources at that time, such as buildings, machines, or cash, were easily secured and the trade cost was relatively low. However, the latest technical difficulty is due to the more rapid obsolescence of machines, and as the products reflecting the firm-specific idiosyncrasy appear, it is known that the factories and machines with the firm' s production technology knowhow determine the product' s competitiveness, and physical resources are as important as intangible resources.

Fixed R&Cs do not continue to bring positive effects (Helfat and Peteraf, 2003). The successful R&Cs in the evolutionary process of firms can rapidly become causes of failure. Therefore, the continuous observation on the R&Cs or the core competence is required. However, they are difficult to measure directly. The identification of their dynamics, when they appear or disappear, is challenging. Little research has been conducted on how the R&Cs are created in the beginning period of firms and how their effects continue. For example, if firms have a certain period of history, because their various experiences affect each other and are entangled, it is difficult to measure which R&Cs affect which aspects of a firm's performance. Therefore, while most of the research conducted considers the long accumulation process of R&Cs important, in reality, the problems of measuring prevent the reliable identification of dynamics of the creation of resources and the accumulation process.

Therefore, to find out the nature/nurture of the R&Cs, the most effective way is to focus on the period immediately before and the establishment of new firms.

3.1.4 Comparison of perspectives on new firms: Convergence and differences

The commonality between organization ecology and evolutionary economics in the perspective of new firms is the concept of selection (Durand, 2001). Organization ecology maintains that to increase the survival rate of new firms, the organization structure should be accountable and reliable enough to be selected by the environment (Hannan and Freeman, 1984), and the niche strategies appropriate for the environment can assist the selection (Carroll, 1985). Evolutionary economics maintains that firms should have the innovation power to have their own idiosyncrasy and make this process a good routine, which drive long-term performance through the process of variation–selection–retention (Campbell, 1965). The current trend in the literature is to interpret the selection as adaption (Lewin and Volberda, 1999).

The biggest differences between organization ecology and evolutionary economics in terms of new firms are the main agency of the selection and the level of analysis. The organization ecology considers the target of analysis as the population of organization and the evolutionary economics considers it as the firms and routines; thus, the direction of selection is external selection and internal selection, respectively (Durand, 2001).

New firms require the application of both of these theoretical perspectives because the important aspect from each theory occurs in the new firms at the same time. The issue of selection from the environment affects the early survival rate of new firms, and the adaption to the environment is the start of the routines that drive the future growth of the firm. Based on the created routine, the firms will continue to evolve and, as Levinthal and March (1993) argue, the search routine of exploration/exploitation will determine the competitiveness and the growth of the firms in the future.

3.1.5 Empirical results of previous firm growth studies

Before the investigation into the effects of the R&Cs on the firms' performance, it is necessary to investigate how the growth of the representative firms has been researched to date.

Economics theories show interest in the relationship between the firm's profitability or productivity and the firm's growth, as this relationship has important implications in allocating scarce resources.

The expansion of firms is equal to the growth of firms, and the reallocation of the scarce resources is necessary for efficient production in the active development of the industry. Intensive research was conducted on the relationship between productivity and firm growth in addition to the profit; thus, the profit and the productivity are the indicators of the firm's performance and become the major interest. Theorists argue that the firms with high performance take the re-investment of the profit in the firm's growth for granted and more efficient firms end up growing more. However, the proofs of the research show that the relationship between firm performance and firm growth was not as positive as expected or even was neutral (Coad, 2009).

Many empirical studies have been conducted on the effects of innovation on firm growth in addition to those concerning profit and productivity. Innovation is the process of producing more advanced output by using the input more effectively; in the relationship between innovation and firm growth, firm growth can be divided into employment growth and sales growth. In this case, employment growth signifies input and sales growth signifies output (Coad, 2009). Management strategies pay attention to the relationship between innovation and sales growth or profit growth, and the economic or policy strategies pay attention to the relationship between innovation and employment growth.

It is generally argued that sales growth has a positive relationship with innovation. However, it is difficult to prove the relationship between innovation and sales growth empirically. This is because a certain time lag is required to see the result of the innovation in the firm' s performance; in practice, while the innovative ideas are implemented as business by going through the middle-process of product innovation or process innovation, which are subject to a rate of failure, the final success rate would be not be high. Therefore, the research result demonstrate that innovation is more effective in a few fast-growing firms rather than in the average firms – that is, it being effective in the higher performers explains the relationship between innovation and sales growth very well (Coad and Rao, 2008). In the firm' s growth, employment growth should be understood by the categories of innovations. Innovation is divided into product innovation and process innovation, and the production innovation has a positive relationship with employment growth. However, concerning process innovation, as the efficiency increases, the number of employee decreases, and recent studies have shown that it has a negative or unclear relationship with employment growth (Hall et al., 2008).

In addition, the firm' s growth is affected by age, size, competition among firms, characteristics of the entrepreneur, and so on (Coad, 2009). A firm' s size and age have a very close relationship, and it is generally known that age and size have negative relationships with firm growth. Research findings have demonstrated that for the first several years, they continue to have the reverse relationship, and only after a certain age do they come to have a positive relationship (Arne and Mulu, 2007). The competition among firms has partial impacts on the firm' s growth; however, this is low compared to the impacts of other factors (Geroski and Gugler, 2004). In reality, new firms are generally small-sized, and if they enter some competitions they tend to lose and exit. It is known that among the entrepreneur' s characteristics, human capital (university degrees) provides positive effects on the firm' s growth (Almus, 2002; Robson and Obeng, 2008), and the founder' s education and experiences contribute to the firm' s growth.

Finally, in terms of the relation between the industry' s characteristics and the firm' s growth, since the high-tech industry has advanced technologies and new products, the firm' s growth rate is high. Therefore, it is recognized that firm growth has a lot to do with the industry regime. In particular, the organization ecology emphasizes the industry-specific factor.

As shown in Table 3, empirical analysis of firm growth has been conducted on the areas that are easy to measure, such as profit, productivity, innovation, age, size, and so on. This is analogous to if the success of human activities is measured as wage growth, the research would look at what firm to go to, education level, age, and so on. Therefore, there is a fundamental departure from the research’ s purpose. The reason for the wage increase can be directly explained by the job and the education level; however, the focus in the present study, in this analogy, would be whether the person’ s talent to finish the education level and to enter that firm is inherited from the parents or nurtured later through various experiences.

Table 2. Previous firm growth and survival studies using organization ecology theory and evolutionary theory

	Key variables	Previous studies
Organization Ecology Theory	Mortality process of organization	· Carroll and Delacroix, 1982; Carroll, 1983; Freeman et al., 1983; Hannan and Freeman, 1989; Hannan and Carroll, 1992)
	Survival of organization	· Hannan and Freeman, 1984
	Formation of companies	· Delacroix and Carroll, 1983; Carroll and Khessina, 2005; Kuilman and Li, 2006
	Innovation on firm survival	· Cefis and Marsili, 2006
	Age and size on firm survival	· Cefis and Marsili, 2006; Oertel and Walgenbach, 2012; Ranger-Moore, 1997
	Legitimacy effect on survival	· Sine et al., 2007; Carroll and Hannan, 2000; Hannan and Carroll, 1992
	Change of organization	· Carroll, 1983; Haveman, 1992; Oertel and Walgenbach, 2012
	Density of a population of organizations	· Hannan and Freeman, 1988; Barnett and McKendrick, 2004; Barnett, 2008
Evolutionary Economics Theory	Firm growth in terms of investment	· Nelson and Winter, 1882
	Inter-firm competition	· Geroski and Gugler, 2004
	Innovation and firm growth rate	· Corsino and Gabriele, 2011

Table 3. Empirical results of previous firm growth studies

Variables	Empirical results
Profit, Productivity	· Positive relationship between profitability and both employment and sales growth (Robson and Bennett, 2000) · A positive relationship between productive efficiency and sales growth (Pavcnik, 2002; Sleuwaegen and Goedhuys, 2002) · A firm's profit rate and its subsequent growth rate as entirely independent (Coad, 2007d) · Financial constraints are not a major problem affecting the growth of firms (Santarelli and Vivarelli, 2007) · Among more profitable firms, higher profits are associated with higher levels of investment. Among the least profitable firms, lower profits are associated with higher levels of investment (Guariglia, 2008) · Both productivity and profitability are positively related to the probability of survival (Bellone et al., 2008) · Employment growth and sales growth are followed by growth of R&D expenditure, while growth of profits has little discernible effect on the subsequent growth of R&D (Coad and Rao, 2009)
Innovation	· Positive relationship between R&D activity and sales growth (Del Monte and Papagni, 2003) · A negative relationship between product innovation and the sales growth of manufacturing firms (Freel and Robson, 2004) · A positive influence of innovation on employment growth in four high-tech US manufacturing industries (Coad and Rao, 2007) · Product innovations generally have a positive impact on employment, while the role of process innovations is more ambiguous (Hall et al., 2008) · Product innovation has no significant effect on the sales growth, while having a strong positive effect on sales growth for the fastest-growing firms (Goedhuys and Sleuwaegen, 2008)

Age, Size, Competition, Entrepreneur, etc.	· Growth and age are inversely related only in the first few years after entry and stay constant for most of the age group until it starts to have a positive relation beyond age 50 (Bigsten and Gebreeyesus, 2007) · Unable to detect any significant effect of rival's growth on firm growth (Geroski and Gugler, 2004) · Better- educated founders faced fewer obstacles to expansion (Robson and Obeng, 2008)

Rewriting source of (Coad, 2009)

Table 4. Results in previous studies on *de alio* and *de novo* firms

Authors	Industry	Description
Mitchell, 1994	Medical imaging	· For dissolution, failure rates of *de novo* firms fall faster with age than *de alio* firms with age. For divestiture, exit rates for *de novo* firms rise faster with age. No difference in the effect of size.
Carroll et al.,1996	Automobile	· *De novo* firms with preproduction begin with lower hazard rates than *de alio* firms; however, this falls more slowly as they age. Size has a larger negative effect on hazard rates for *de novo* firms than for *de alio* firms.
Klepper and Simons, 2000	Television	· Survival rates of *de alio* firms are much higher than *de novo* firms in the last period when the industry faced disruptive technology change from color TV and semiconductors. The authors infer that *de alio* firms continued to innovate in the face of new technology, while *de novo* firms did not.
Holbrook et al.,2000	Semiconductors	· While *de novo* firms saw early success with technology, *de alio* firms managed the industry transitions to new technology more successfully than *de novo* entrants.
Klepper, 2002a	Automobile	· Age increases the failure rate for *de novo* firms but not *de alio* firms. Experienced firms generally entered earlier, and see declining hazard with time.
Kelpper, 2002b	Automobile, tires, television, penicillin	· In auto and tires, the study does not find evidence for convergence. In television and penicillin, there is evidence for divergence of the two types.
Bayus and Agarwal, 2007	PC industry	· *De novo* firms failed at higher rates than *de alio* firms after the transition to a new technology regime.

Source: (Chen et al., 2012)

3.1.6 Pre-entry or post-entry resources and capabilities for firm growth

Empirical analysis on firm growth is mainly on profit, productivity, Innovation, Age, Size, Competition, and so on as, as discussed above. These variants are the results of the R&Cs, and the eventual causes to the firm' s growth cannot be explained directly.

If new firms are established with the support from their parent firms and receive a lot of resources, they have high inherited resources. In addition, the multi-aspect firms (or spin-off firms from the parent firms) can have pre-entry experiences in the form of inherited R&Cs. On the other hand, after the establishment, the firms experiencing a lot of post-entry effort by increasing the physical assets or human resources or conducting vigorous R&D activities can increase nurtured R&Cs. The experience described here can be used as the proxy variable of the firm' s capabilities (Kogut and Zander, 1992; Teece et al., 1997; Zollo and Winter, 2002). Firms continue to gain experiences and accumulate learning, and this is linked to the capabilities, which is the basic concept.

The learning model that affects the firm' s performance in the nature/nurture perspective is divided into "passive learning" and "active learning" (Brown and Earle, 2011). The passive learning model uses the logic that the value of the R&Cs that firms have is known through the post result (Jovanovic, 1982). That is, the R&Cs are determined at the same time when firms are established. For example, if the firm' s productivity is fixed and determined only by the inherited capabilities without nurture, the firms' productivity level is already determined, and its location is already determined within the set productivity distribution at the establishment, it does not have any effects on the result (Hopenhayn, 1992). This is the theory focusing on the effects of the inherited R&Cs.

On the other hand, the active learning model uses the logic that if firms intend to increase productivity, they can increase the investment, and it acknowledges the roles of the nurtured R&Cs (Ericson and Pakes, 1995). When the management and policy-makers plan to establish new firms or judge the performance, depending on which model they refer to, the management strategies and policy directions will determine whether they focus on securing the inherited R&Cs or nurtured R&Cs.

3.1.7 **Resources and capabilities through pre-entry experience**

The relationship between the pre-entry experience and knowledge and the long-term performance and survival of firms has been studied extensively (Agarwal et al., 2004; Brüderl et al., 1992; Carroll et al., 1996; Delmar and Shane, 2006; Evans and Leighton, 1989; Fontana and Nesta, 2010; Franco and Filson, 2006; Gimeno et al., 1997; Klepper, 2002a; Klepper and Simons, 2000; Mitchell, 1989). In particular, in the perspective of organization ecology, the research on the *de alio* and *de novo* dichotomy has focused on identifying the effects of the pre-entry experience, and in recent studies effects have been summarized (Chen et al., 2012).

Advanced studies on *de alio* and *de novo* have been conducted with various industries. Numerous studies have been conducted on the U.S. automotive industry

(Carroll et al., 1996), medical device industry (Khessina, 2003; Mitchell, 1994), semi-conductor industry (Hannan and Freeman, 1988), computer-manufacturing industry (Barnett et al., 2003; Swanson, 2002), European automotive industry (Hannan et al., 1998), world optical disk drive industry (Khessina and Carroll, 2008) and so on. While the studies have focused on survival and extinction in the organization ecology perspective, the research extends to entire industries and individual firms.

De alio and *de novo* firms may enter the market together; however, depending on the existence/type of the pre-entry experience, firms start in different organizational types and, eventually, the pattern of innovative activities (Khessina and Carroll, 2008) and marketability (Carroll et al., 1996) are represented differently.

As for *de alio* firms, with the pre-entry experience, since it receives sufficient supports from the existing firms with resources, capital and human labor (Mitchell, 1994), entering the new industry would not be a problem (Levinthal, 1991). The resources, capabilities and brand value received from the previous firms increase the firm's market share (Klepper and Simons, 2000) and enable the firm to stay in the market for a long time (De Figueiredo and Kyle, 2006). The stable organizational system and manufacturing routines enhance the product's credibility and increase the success rate in the market (Hannan and Freeman, 1984). In addition, the experience in the market enables the products to be promoted effectively (Nerkar and Roberts, 2004), and the new products relevant to the reputation of its parent firm will have better positions in the promotion when they are first released (Podolny, 1994; Swanson, 2002).

On the other hand, *de novo* firms, without pre-entry experience, have less R&Cs than *de alio* firms; however, numerous studies have demonstrated an advantage in terms of flexible organization and the prompt responsiveness to the change of environment (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firms tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008). It is common sense that innovative firms survive longer in the market (Stavins, 1995). In the case of *de novo* firms, there is no choice but to depend on its own innovative technology from the beginning compared to *de alio* firms. In a sense, since it is naturally free from the technological traces that a parent firm holds, *de novo* firms have an inborn tendency to try innovative technologies. It makes an effort to acquire the best technology and tends to have a business structure fit for the competition in the most advanced technological areas in the chosen market. *De novo* firms can have an advantage of making a prompt response to the technological change over *de alio* firms, which compete in a wide range of areas with various products; however, they are burdened with a higher risk due to not receiving any supports from the existing resources.

The development of *de novo* firms was difficult to interpret in the resource-based view. While it is rational to explain the high survival rate of *de alio* firms with the relatively superior R&Cs in the organization ecology perspective, it is insufficient to explain the success examples of *de novo* firms.

Given this shortcoming, the current research intends to confirm that if *de novo* firms, despite their insufficient inherited R&Cs, add the post-entry efforts through the flexible organization and innovative operation, the nurtured R&Cs can be expected to be created, and the post-entry effort is as important as pre-entry experience to the firm’s growth. Pre-entry knowledge and learning affect the growth and survival of new firms as much as pre-entry experience (Dencker et al., 2009). The position of organization ecology is that firms with pre-entry experience or pre-entry knowledge have higher likelihoods of survival in the environment and that these pre-entry R&Cs continue to provide direct assistance in this respect. On the other hand, in the evolutionary economics perspective, since the pre-entry experience and knowledge plays a role in firms acquiring and increasing capabilities to adapt to the new environment, they path-dependent and indirectly affect the firm’s long-term performance (Dencker et al., 2009).

The question here is whether the effects of the pre-entry experience are direct or indirect and how long the effects last. However, it is difficult to draw a clear conclusion here. As seen in Table 3, until recently there have been mixed results on the effects of pre-entry experience on the characteristics of *de alio* and *de novo* firms – that is, results of the inherited R&Cs changed over time. Recent studies have maintained that the durability of the effects of pre-entry experience can vary depending on the firm’s post-entry effort (Thompson, 2005).

3.1.8 **Resources and capabilities through post-entry effort**

As explained before, pre-entry experience and post-entry efforts are the experiences before/after the establishment of a firm. While the pre-entry experience research has been known widely through the research on *de alio* and *de novo* in organization ecology, unfortunately there have been few researches on the post-entry efforts. After the post-entry, the detailed and special experience linked to the firm’s performance records cannot be one or two and the interactions among experiences have compound effects on the firm’s performances. Rather, in evolutionary economics perspective, there have been some arguments that the pre-entry experience has direct effects on the firm’s performance but also increases the firm’s learning capability and adaption to the environment and continues to have effects even after the establishment (Dencker et al., 2009; Nelson and Winter, 1982). However, the current research intends to prove that it was the result ignoring the fact that the experience right after the establishment can be the start of the firm’s routine (Deakins and Freel, 1998).

Reviewing a few available existing researches, the researches dealing with firm’s initial business activities and experiences analyze how the initial experiences have impacts on the survival of the firm and the short-term performance. Theoretical and positive analyses are available on the impact of experiences such as operating experience (Kim et al., 2009), problem solving experience (Hugo and Garnsey, 2005), success experience (Aldrich, 1999; Cyert and March, 1992), recovery experience (Hambrick and Schecter, 1983) and so on that firms experience in the beginning on the performances. Especially, Deakins and Freel’s research (1998) explains that the initial activities of a firm affect the learning of a firm organization and the formation of its routine. In the experiences and activities that a business organization undergoes, the firm learns in a method of trial-and-error and it is internalized inside the organization as the firm's own problem-solving method, response to the change of environment, culture, and so on and becomes a routine (Deakins and Freel, 1998).

New firms will estimate their R&Cs with or without their pre-entry experience (Helfat and Lieberman, 2002), judge whether they fit to the new market environment or not and eventually enters the market. Therefore, pre-entry experience can be the decisive factor on the post-entry effort. Thus, dividing the effects of the post-entry effort and those of the pre-entry experiences can be an important process. That is, the post-entry effort should focus on the firm's raising of the R&Cs through the process of firm's learning by doing for a certain period of time right after the establishment. To explain the effects of R&Cs through post-entry effort properly, the operation management should be improved and the activities on capital investment (Thompson, 2001), R&D investment on the manufacturing facilities (Sinclair et al., 2000) and the individual worker's experience (Lazonick and Brush, 1985) due to the increase of the labor forces should be limited to the early activities of the firms.

The firm's performance cannot be explained with only one frame; either inherited R&Cs or nurtured R&Cs. However, the argument that both of them made impacts needs still more discussion. Considering the 100-year-old dispute over nature vs. nurture and nurture via nature on the causes of human behavior, the dispute over nature vs. nurture on the growth of firms has just started.

3.2 Research hypothesis

This present research seeks to determine the extent to which the R&Cs are given as an inborn endowment or an acquired ability. The new firm' s pre-entry experience and post-entry effort (instead of the firm size and age) will be discussed to examine how they affect the firm's growth.

New firms' establishment and growth processes are analyzed with the theoretical framework of organization ecology and the evolutionary economics integrated in the perspective of selection and adaptation (Fortune and Mitchell, 2012). In the organization ecology perspective, the effects of the natural/inherited R&Cs on the firm's growth can be explained. Also, in the evolutionary economics perspective, the effects of the nurtured/acquired R&Cs on the firm's growth can be explained in this research. The resource-based view explains how the R&Cs are created through various experiences and also how they explain the firm dynamics, which eventually dictate firms' future growth. Thus, the resource-based view combines and elaborates the organization ecology and evolutionary economic theories. This research places an emphasis on the determination of the firm's growth with the theoretical reasons, and compares the effect of inherited R&Cs and nurtured R&Cs on firm growth.

Do pre-entry R&Cs have long-term effects on the firm's growth?

Some firms begin with sufficient R&Cs (*de alio* firms), while some start the business only with an attraction to the market (*de novo* firms). This raises the question of how the growth of firms with the insufficient R&Cs can be explained. Conversely, how can the failure of firms with sufficient R&Cs be explained?

Many researches on *de alio* and *de novo* firms demonstrate that inherited R&Cs are determined by the pre-entry experience and the survival rate of *de alio* firms is high due to their R&Cs. The problem is that the effects of pre-entry experience change over time. This also means that the characteristics of the organization change as time passes. As for *de alio* firms, the R&Cs have a tendency to generate the side effects of organizational inflexibility and inertia after the initial stage of market entrance. As for *de novo* firms, as their organization is flexible to the environmental changes, the R&Cs can be accumulated, and the speed of product obsolescence slows over time. There is a tendency to catch-up with the rate of *de alio* firms' products (Khessina and Carroll, 2008). Of course, after a certain period of time, *de novo* firms the same difficulty due to the inertia that *de alio* firms face (Carroll et al., 1996).

These results occur because the organization ecology perspective does not consider the firm's distinctiveness, focusing only on the firm's survival and extinction. This is because the various experiences that each firm undergoes following establishment are not reflected. Therefore, the detailed reasons for the change of organizations are not considered. To see more precise effects of the pre-entry experiences (i.e., inherited R&Cs), it is desirable to analyze the growth rate of firms and the performance differences over time rather than the survival rate of firms.

By analyzing the growth rates (and there continuance) of *de alio* and *de novo* firms, a clear conclusion can be obtained as to the effects (and their continuance) of the inherited R&Cs on the growth of firms.

According to the literature, *de alio* firms have resource and capability advantages while *de novo* firms have an organizational flexibility that enables them to adapt to changes in their business environment. However, the research has focused on how these advantages influence their survival, thus ignoring the question of how one group's advantages help them compete with the other group and affect the time-lag changes in their growth pattern. Unfortunately, very little research has been done on these issues. Therefore, this study intends to fill this research gap by investigating the competing dynamics behind the firms' corporate growth and growth patterns.

To do this, the new and renewable energy industry, in which *de alio* and *de novo* firms are evenly distributed and novice producers. These two industrial characteristics can minimize the indirect externalities arising from the industry itself. Therefore, the new and renewable energy industry is an excellent choice for an analysis of the patterns of corporate growth resulting from different entry modes.

From these two, pre-entry and post-entry, R&Cs, which one would have a long-term effect on the growth of a firm?

As for the new firms, , the firms' R&Cs upon market entry are determined depending on the type of pre-entry experience (Helfat and Lieberman, 2002). This determines not only the post-entry performances but also the long-term survival or growth of firms. The appropriate firm is selected to the environment, and will continue to grow. In this case, the firm's growth is dependent on the inherited R&Cs. On the other hand, after entering the market, if the firms continue to develop the R&Cs dynamically by means of the post-entry effort, the learning by doing process, and perform well, they will survive. In this case, the firm's growth is said to be dependent on the nurtured R&Cs. The pre-entry experience and the post-entry effort will be categorized as the nature/nurture of the R&Cs. Furthermore, by comparing and analyzing the effects on the firm's growth in respect to pre-entry experience and post-entry effort, one can determine whether inherited or nurtured R&Cs are more beneficial to the firm's growth. In this case, the post-entry effort generating the nurtured R&Cs should be categorized as a type and should be measured in detail. In addition, by limiting the period of post-entry effort, the compound effect of the R&Cs over time is minimized, and its effect on the future growth of firms can be more clearly identified.

As good habits last long and these habits are eventually linked to performance, the new firm's good routines can influence the evolution process of the firms and finally affect the firms' long-term performance. However, not every post-entry effort is beneficial. It depends on the type of industry and growth rate: higher-growth firms and lower-growth firms.

To prove this, Chapter Five will examine the effects of the pre-entry experience and post-entry efforts in the manufacturing industry concerning the firms' short- and long-term performances. The manufacturing industry can be categorized into high-tech industry and low-tech industry. Since there are enough new/existing firms, the manufacturing industry is proper to compare the pre/post-entry efforts and to categorize the various types of post-entry effort.

Can the arguments of nature vs. nurture on the R&Cs usefully inform managers or policy makers?

The arguments of nature vs. nurture concerning new firms' R&Cs will provide very important implications to the policy makers as well as managers. New firms' entries and exits play very important roles in economic development and the creation of jobs (Stel et al., 2005; Thurik, 2003). Additionally, as seen in Barnett and Burgelman's (1996) research, which analyzes Intel's changing process of strategies from the evolutionary perspective, insight into the internal R&Cs will provide very important execution-ability to the management strategies (Barnett and Burgelman, 1996; Burgelman, 1991). The result of the dispute as to the extent to which the growth of firms is caused by nature or nurture will/should have a significant impact on the strategic judgment of both policy-makers and managers. If the growth of firms is affected mainly by the inherited R&Cs, the new firms must prepare such R&Cs sufficiently before entering to the market.

Furthermore, the start-ups or venture firms that have limited inherited R&Cs or no special technologies should be protected by central policy.

The existing firms would understand that the strategies of diversification or spin-off have a higher success rates rather than the venture investment. On the other hand, if the firm's growth is strongly affected by the nurtured R&Cs, the firms should actively change their existing R&Cs. In addition, they should develop the organizational structure to enable the continuous development of internal capabilities. In particular, the initial period of new firms should place the sufficient efforts on developing their R&Cs and rather than solely or mainly on increasing the size of their firms. The start-ups or venture firms, which show a high possibility to develop their capability, should be supported by relevant policies.

Chapter 4. Growth Pattern of De Alio and De Novo Firms in the New and Renewable Energy Industry

4.1 Introduction

Understanding the factors central to firm success and the sources of corporate growth is an important but difficult task for entrepreneurs and policymakers. A steady stream of diverse arguments on and evidence for firm growth indicates this; in fact, there is no unanimity, even among scholars. Grasping firm growth patterns is difficult, given the lack of information on industries. Making matters worse is the volatile external environment, in which firms frequently enter and exit their industries and where industries are highly sensitive to technological trends.

Understanding corporate growth patterns would be furthered if we could track the history of firm growth from its initial stage, firm entry. Patterns of firm growth and decline are determined by factors such as R&Cs either inherited from parents or earned during pre-entry experience, R&Cs gained through learning by doing, and the firm's absorptive capacity.

Our research focuses on the growth pattern of two types of market entrants: firms with inherited R&Cs and firms with no inheritance but innovative capabilities and organizational flexibility. To compare the key characteristics of the two entry modes, we conduct an empirical analysis on firms in the new and renewable energy industry, an industry that provides a good fit for our analysis, as both the pre-entry experience and innovative capabilities are important firm assets in this industry. Our classification of market entrants into *de alio* and *de novo* types is driven by whether the firms have those two assets. *De alio* and *de novo* firms both have strengths. *De alio* firms such as spinoffs and diversified companies benefit from R&Cs gained through pre-experience, whereas *de novo* firms such as start-ups and venture businesses enjoy organizational flexibility and innovative capabilities (Helfat and Lieberman, 2002). This study analyzes the growth patterns of the two groups of new and renewable energy firms by comparing their growth rates.

De alio and de novo firm characteristics

De alio and *de novo* firms entering the market together begin as different organizational types and eventually follow different innovation patterns depending on their pre-entry experience (Khessina and Carroll, 2008) and their marketability (Carroll et al., 1996) is represented differently. As *de alio* firms with pre-entry experience receive sufficient support from existing firms with resources, capital, and human labor (Mitchell, 1994), their entry into new industries is not problematic (Levinthal, 1991). The resources, capabilities, and brand value received from the previous firms increases a firm's market share (Klepper and Simons, 2000) and allow it to stay in the market for the long term (De Figueiredo and Kyle, 2006).

Though *de novo* firms without pre-entry experience have fewer R&Cs than *de alio* firms, research has proven that they have the advantage of flexible organization and the capacity to respond to environmental changes promptly (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). *De novo* firms tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008). *De novo* firms that have not inherited resources and capacities from parent firms have no choice but to depend on their own innovative technologies, unlike their *de alio* counterparts. They strive to acquire the best technology and tend to have business structures fit for competition in the most technologically advanced arenas.

Studies on industry dynamics have analyzed how firm survival depends on entry mode (*de alio* vs. *de novo*) in various industries (Carroll et al., 1996; Khessina and Carroll, 2008; Swanson, 2002). This study empirically investigates whether *de alio* or *de novo* firms grow faster and sustain their growth in the new and renewable energy industry.

The new and renewable energy industry is growing rapidly, and its firms' growth is considered more important than their exit and organizational restructuring.

New and renewable energy industry characteristics

Since the 1973-74 oil crisis, the new and renewable energy industry has become one of the most attractive investment destinations in the world. A surge in R&D investment in this sector was expected to continue but began to falter in the 1980s. This infant industry then began to steadily develop in the 1990s (Schilling and Esmundo, 2009).

It is still a promising global market. The IEA (2012) expects that global energy demands will increase by more than 30 percent by 2035, and many have raised environmental concerns over the rapidly increasing consumption of fossil fuels. The IEA (2012) also estimates that the new energy industry has an almost 30 percent share of the global energy mix and that global government subsidies will increase from 88 billion dollars globally in 2011 to nearly 240 billion dollars in 2035 (IEA, 2012).

Market stabilization is still nowhere in sight, despite the global spotlight on and growing investment in this industry. For decades, technology has developed a variety of new and renewable energy sources such as biofuel, solar cell, and wind power. However, this energy industry is still in its infancy and has been falling behind fossil fuels in terms of price competitiveness, being highly dependent on government policies and oil prices. The market landscape has made entrepreneurs hesitant to risk investing in this fledging industry. Against this background, however, wind power had an annual growth rate of 23.7%, and solar photovoltaic grew by 36.1% between 1990 and 2006 (Johnstone et al., 2010). Such high growth rates have suggested a bright future for the new and renewable energy industry. Both companies reaching their growth limits and innovative fledgling firms can seize the opportunities being offered in this sector.

In order to sharpen competitiveness in the new and renewable energy industry, companies should equip themselves not only with R&Cs but also with organizational flexibility and innovative capacity to overcome market uncertainty. Thus, a comparison between the growth patterns of *de alio* and *de novo* firms in this industry will deepen our understanding of firm growth. The new and renewable energy sector has an even distribution between *de alio* and *de novo* entry modes. In an emerging sector like this, *de alio* and *de novo* firms have few significant technological differences, and neither enjoys advantages in an unstable market. These industrial characteristics can minimize the indirect externalities arising from the nature of the industry, allowing us to effectively analyze the firm growth patterns subsequent to different entry modes. Aside from the question of inherited R&Cs, *de alio* and *de novo* entrants compete on an equal footing in the new and renewable energy industry. Therefore, this industry best fits our research goals.

The paper examines two research questions:

(1) Which type of entrance (de alio or de novo) achieves faster sales growth, and

(2) How long does this effect last in the new and renewable energy industry?

We expect that *de alio* firms have higher sales growth rates than *de novo* firms in the early years because the former can begin operating in more favorable conditions due to their inherited R&Cs. As time goes on, however, the gap between *de alio* and *de novo* firms will narrow and finally disappear. In the short term, pre-entry experience's effect on firm growth is stronger than that of innovative capacity and organizational flexibility. In the mid to long term, large *de novo* firms accelerate their growth and eventually catch up with the *de alio* firms. In the longer term, *de novo* firms can acquire R&Cs through learning by doing, at which point *de novo* firms acquire *de alio* status. Therefore, we expect that dividing firms into *de alio* and *de novo* types to compare their growth rates serves no purpose. We perform additional analyses by using a quantile regression to show how the gap between *de alio* and *de novo* firms changes for high-growth firms.

This research is significant in that it relates *de alio* and *de novo* firms' growth to the characteristics of their industry. It analyzes which entry mode (*de alio* or *de novo*) is more advantageous for growth and reveals how long the entry condition can be maintained. For companies considering diversification or establishing new companies for new businesses, this study can assist strategic decision making by indicating the factors that should be emphasized depending on the resources available and the type of organization. This study can also provide policy makers with clues as to whether promotion for diversification or investment is more effective for a start-up firm in a new and growing industry.

The remainder of this paper is organized as follows: in section 4.2, the literature on firm growth and entry modes are reviewed. Section 4.3 explains the research structure and model. And, section 4.5 presents the summary based on the empirical results in section 4.4.

4.2 Previous studies

4.2.1 Traditional factors in firms' growth

There are four views of firm growth patterns. One is the resource-based theory, which discusses the effects of retained resources. The second view concerns the effects of dynamic innovative capabilities. The third view analyzes the effects of age and size based on the stylized facts. Last, there is the view that investment in innovation and innovative activities have an influence on firms' growth.

First, the strategic management view on R&Cs is often used to discuss the growth of firms that have already grown to a certain size when they establish their business. The abundant resources and specialized core capabilities of such firms lower their risk in the market and act as leverage for new opportunities. R&Cs such as capital, technology, organizational structure, and knowledge from experience are constantly cumulated and transferred for a firm's continuous growth (Teece and Pisano, 1994). A company properly equipped with R&Cs is able to make gradual innovative actions through organizational routines, but may be handicapped by not being able to respond quickly to sudden environmental changes because of less flexibility because of inertia resulting from the firm's large size (Christensen et al., 2004).

Second, innovative capability refers to a firm's growth in a technology-intensive industry. New entrants are not affected by conventional rules, as they do not have any inherited resources or capabilities. New companies tend to focus on what they do best, relying on their core technology. They can respond quickly to environmental changes because they are small and flexible (Hannan and Freeman, 1984; Haveman, 1992). In the beginning, entrants may take the lead in terms of technology; however, some of them fail because they lack resources, capabilities, brand value, and experience (Bruderl et al., 1992).

Third, a branch of research has linked firm growth to age and size. In the early stage of research, there was conflict between the findings of two studies: one states that larger firms have higher growth rates (Singh and Whittington, 1975), while the other states that younger, smaller firms have higher growth rates (Evans, 1987a). Afterward, (Hart and Oulton, 1996) found that the reverse relationship between a firm's size and growth is valid only for small- and medium-sized enterprises while it is not valid any more for large sized enterprises.

Firms age has been widely used as an essential variable when firm's growth is regressed, implying that older firms achieve lower growth rates (Dunne and Hughes, 1994; Evans, 1987a). As a firm gets older, it faces trade-offs between positive factors such as experience, reputation, track records, and financial trust and negative factors such as inertia, routine, and bureaucracy. Eventually, negative factors overwhelm positive ones in older firms.

Fourth is an innovation achievement. A number of theories identify a positive correlation between company growth and innovation achievements, although many empirical studies have shown non-satisfactory results. Some have reported no relationship between the two (Bottazzi et al., 2001). It may be difficult to clearly define the relationship between innovation and firm growth because only a small number of firms grow within the tent-shaped distribution of the growth rate and because regression analysis finds average trends of population.

These four views do not conflict with one another; they are closely related. The emphasized points in these four growth patterns can be categorized into static and dynamic factors. Size and available resources can be considered as static factors and dynamic capabilities, and innovative activity can be regarded as a dynamic factor. Thus, it is important to consider these static and dynamic factors in studies on firm growth.

This study is intended to determine which of the two market entrants is in a more advantageous position for firm growth in a fledgling industry like the new and renewable energy industry—*de alio* firms born with a silver spoon in their mouth or *de novo* firms born without it but with organizational flexibility and innovative capacity. To answer our research question, we divide market entrants into two subsectors and use variables such as size, age, R&D investment, and profitability as control variables.

4.2.2 Previous studies on *de alio* and *de novo* firms

There are several difficulties in analyzing whether a firm with strength in terms of static factors, such as abundant resources, or a firm with strength in terms of dynamic factors, such as organizational flexibility, achieves a higher growth rate. First, it is hard to distinguish whether a company has abundant resources or a flexible organization, and this can change over time. An effective means of distinction could be to categorize entrants as either *de alio* or *de novo*. *De alio* refers to the firm that has their parent company or has experience in other industries, and which become diversified companies or parent spin-offs. *De novo* refers to the firm without a parent company or business experience (Helfat and Lieberman, 2002). *De alio* and *de novo* firms may exhibit differences in their patterns of innovation activity (Khessina and Carroll, 2008) and market achievements (Carroll et al., 1996) because of their different organizational structures.

Prior studies on *de alio* and *de novo* firms have been conducted on various industries, including the semiconductor industry (Hannan and Freeman, 1988), the U.S. automobile industry (Carroll et al., 1996), the European automobile industry (Hannan et al., 1998), the medical equipment industry (Khessina, 2003; Mitchell, 1994), the computer manufacturing industry (Barnett et al., 2003; Swanson, 2002), and the world optical disk drive industry (Khessina and Carroll, 2008).

D*e alio* firms are likely to be exposed to less danger in the early stage because they usually receive sufficient resources, capital, and human resources from their previous companies (Levinthal, 1991; Mitchell, 1994). This heritage from a previous firm includes resources, capabilities, and brand value, and enable *de alio* firms to obtain a higher market share (Klepper and Simons, 2000) and survive longer (De Figueiredo and Kyle, 2006). The stabilized organization structure and production routine enhance consumer trust in products and increase the firm's chances of success (Hannan and Freeman, 1984). Their experience in other markets enables them to more effectively advertise their products (Nerkar and Roberts, 2004), and the wide spectrum of products and reputation of their parent companies are useful when advertising (Podolny, 1994; Swanson, 2002). For these reasons, Carroll et al. (1996) proved that the survival rate of *de alio* firms is higher than that of *de novo* firms at the initial stage in the U.S. automobile industry. In other case, Khessina (2008) stated that the products of *de novo* firms would be withdrawn earlier from the market than those of *de alio* in the world optical disk drive industry.

On the other hand, various empirical studies have shown that *de novo* firms can become more flexible in their organizations and can more quickly respond to environmental changes than *de alio* firms (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firms produce innovative products based on their advanced technology (Khessina, 2003; Khessina and Carroll, 2008). It is common knowledge that innovative firms survive longer (Stavins, 1995). As *de novo* firms do not have any resources or capabilities inherited from a parent company, they must rely on innovative technology. Indeed, they may have an innate tendency to attempt free technology innovation without technical constraint from such a parent company. In many cases, *de novo* firms have business structures designed to acquire the best technological knowledge and compete in the area of the latest technology.

On the other side, *de novo* firms are exposed to greater risk because there is no support available. As is typical of industries with short product cycles, if *de novo* firms lose their reputation, they will tend to disappear from consumers' interest, which makes survival more difficult for them than for *de alio* firms (Khessina and Carroll, 2008).

A common factor between *de alio* and *de novo* firms is that their organizational characteristics change over time. *De alio* firms face side effects based on the stiffness of their organizations and problems of inertia that once contributed to their survival. Similarly, the survival rate of *de novo* firms will converge to that of *de alio* firms as *de novo* firms accumulate R&Cs over time (Khessina and Carroll, 2008). Of course, after a certain period of time, *de novo* firms can suffer from the same inertia problem (Carroll et al., 1996).

In conclusion, previous studies on the survival of *de alio* and *de novo* firms clearly distinguish the advantages and disadvantages of the two entry modes. This study aims to expand the understanding of the effect of entry modes on firms' survival and growth, including whether previous R&Cs or innovative flexibility is more effective for firm growth, and how long such an effect would last.

Table 5 shows characteristics of entrant type and classification of *de alio* and *de novo* (Helfat and Lieberman, 2002).

Table 5. Entrant type and entry modes

Entrant type	Legal relationship of entrant to established firm	Modes of entry	Parent firm ownership	Type
Diversifying entrant	Same legal entity	Internal growth Acquisition	Full	*De alio*
Parent-company venture	Separate legal entity: Founded by established firm	Joint venture Franchise Parent spin-off	Partial	
De novo entrant	Separate legal entity: Founder previously employed by an established firm, No prior employment or financial relationship	New entrepreneurial spin-off, New start-up	None	*De novo*

Source: (Helfat and Lieberman, 2002)

Table 6. The impact factor and proxy variables for firm growth

	Previous studies	Proxy variables
R&Cs	The abundant resources and specialized core capabilities of such firms lower their risk in the market and act as leverage for new opportunities. R&Cs such as capital, technology, organizational structure, and knowledge from experience are constantly cumulated and transferred for a firm's continuous growth	De alio
Innovative capability	New entrants are not affected by conventional rules, as they do not have any inherited resources or capabilities. New companies tend to focus on what they do best, relying on their core technology. They can respond quickly to environmental changes because they are small and flexible	De novo
Size and Age	that larger firms have higher growth rates, while the other states that younger, smaller firms have higher growth rates(Evans, 1987a)(Evans, 1987a). As a firm gets older, it faces trade-offs between positive factors such as experience, reputation, track records, and financial trust and negative factors such as inertia, routine, and bureaucracy.	Sales, Employment Age
Innovation achievement	A number of theories identify a positive correlation between company growth and innovation achievements, although many empirical studies have shown non-satisfactory results.	R&D intensity Profit ratio

4.3 Research design and analysis model

4.3.1 Research questions

This study addresses two questions. First, in regard to firm growth, this study considers whether a *de alio* firm, given the accumulated R&Cs of its parent company, has a relative advantage or disadvantage compared to a *de novo* firm, which possesses innovative products and a flexible organizational structure. In the field of firm demography, which explains firm birth, growth, death, and other related topics demographically, *de alio* and *de novo* studies have focused predominantly on firm survival and the lifespan of products. This study finds another focal strength in that it has expanded relevant studies to firm growth.

Second, this study addresses the question of how long the effect of entry modes on firm growth last. In previous studies, *de alio* and *de novo* studies were conducted under the premise that the influences resulting from the differences in entry modes continue until a company closes. However, in reality, it is likely that the effects of entry modes may become diluted over time, and may even, with ample time, have no significant effect at all. Considerations of the effective length of entry modes differentiate this research from previous studies.

Recent *de alio* and *de novo* research has focused on identifying the effects of pre-entry experience; updates have been released (Agarwal and Helfat, 2009; Chen et al., 2012). However, this study is interested in how these advantages influence firm survival, which overlooks the question of how advantages help one group compete with the other group and how the time lags change in the growth pattern. Unfortunately, very little research has been done on these issues. Therefore, this study intends to fill the research gap by investigating the competing dynamics behind firm growth and growth patterns. To do this, we chose the new and renewable energy industry, in which *de alio* and *de novo* firms are evenly distributed and are both novice producers, industrial characteristics that can minimize the indirect externalities arising from the industry. Therefore, the new and renewable energy industry is an excellent choice for our analysis of the patterns of firm growth resulting from different entry modes.

4.3.2 **Data collection and analysis model**

In this study, data on globally listed companies was collected from the Thomson Reuters Datastream and analyzed through panel analysis. This study was conducted in accordance with the classification criteria provided by FTSE's Industry Classification Benchmark (ICB). Furthermore, firms in the new and renewable energy industry that are included in this study were listed in the "alternative sector" of the ICB; data on 298 companies were available.

The new and renewable energy industry is still in a growth stage, and most small companies' R&D efforts have yet to be commercialized successfully. Facing data limitations, this study confined its analysis to publicly traded firms that produce actual sales in order to compare the sales growth rates of *de alio* and *de novo* firms.

This study collected the data from the lists of globally listed companies provided by Thomson Reuters Datastream. The sample selection bias might have occurred because our data cannot represent all companies in the new and renewable energy industry. When the new and renewable energy industry reaches maturity, the number of firms will be large enough to correct the sample selection bias. This study has this to future research.

For new and renewable energy, the International Patent Classification (IPC) classifies the energy sources into wind, solar, geothermal, ocean, biomass, and waste (Johnstone et al., 2010).

Among these, biofuel has advantages over other fuels. Its extraction from biomass involves relatively simple technology, and it can immediately be used as a liquid transportation fuel. After the 1970 oil crisis, the world turned its eyes to biofuel. Since the 1980s, this energy source has steadily increased its share of the global market mix. Wind power and solar energy are the best fit for a distributed energy model. We can use existing grids to transmit electricity generated from wind power or solar energy and separate devices to transmit electricity from solar energy. Since the 1990s, governments have been competitively subsidizing new energy development, and businesses have accelerated their commercialization efforts. However, there is a long way to go before solar energy can be commercialized, largely due to its weak price competitiveness against fossil fuel despite the considerable cost reduction efforts (Schilling and Esmundo, 2009).

Thus, the sources of new and renewable energy differ in terms of technological development, product shapes, and industrial development. Given this industrial landscape, we divided new and renewable energy into the equipment and fuel subsectors.

The equipment subsector comprises a group of equipment producers efficiently generating electricity from new energy sources; the equipment producers of solar cells, wind power, and fuel cells are good examples.

The fuel subsector includes the producers of alternative fuels such as biomass fuel. In the equipment subsector, firms with a high level of technology have the advantage.

In the equipment subsector, firms are more likely to survive if they have high levels of technology that can efficiently generate electricity; thus, they should have strong product innovation. Meanwhile, using their current infrastructures and fuel production facilities, producers in the fuel subsector can produce and commercialize biofuel immediately if they have the technology to convert biomass to biofuel. Therefore, firms already equipped with fuel facilities and technological expertise can enter the market through diversification and are more likely to survive.

The new and renewable energy industry still requires much technological development. This energy's development strategy includes technological development, efficiency improvements in production, and the introduction of sources of new and renewable energy (Lund, 2007). In the new and renewable energy sector, firm survival depends on whether firms can efficiently generate electricity from new energy sources and develop cheap alternatives to fossil fuels. This industry has the huge potential to replace the existing energy industry. However, considering the external business landscape, where price competitiveness is determined by oil prices, all market entrants in this industry are exposed to a similar level of uncertainty.

Not only has this study carried out a differentiated analysis on *de alio* and *de novo* firms, it has also analyzed the effects caused by the differences in the equipment and fuel subsectors. Using concepts such as innovative technology, appropriability, cumulativeness, and knowledge base, as presented in (Malerba and Orsenigo, 1997), equipment manufacturing industries and fuel production industries can be grouped according to their industrial characteristics, as shown in Table 7. The equipment and fuel subsectors both fall under the category of “new and renewable energy related companies,” but there exist clear distinctions between manufacturing equipment and producing fuel in regard to industrial characteristics. Consequently, the analysis was conducted taking into account the fact that these distinctions may have different influences on *de alio* and *de novo* firms’ growth patterns.

The history and financial information for industries provided by Thomson Reuters was used as the primary data to determine the differences between *de alio* and *de novo* firms and between the equipment and fuel subsectors. For companies for which sufficient information was unavailable, their internet homepages were used as secondary sources. Distinction between *de alio* and *de novo* firms was done through comprehensive consideration of a number of factors, including the existence of a parent company or subsidiary companies, former firm names, firm history at the time of establishment, and the firm’s list of products.

Table 7. Characteristics of the new and renewable energy industry according to the industrial regime

Regime type	Equipment subsector	Fuel subsector
Opportunity for innovation	・For product innovation, it requires the development of materials and equipment simultaneously. ・It requires knowledge from a variety of fields. ・The success rate of product innovation is not high.	・New knowledge as well as existing fuel production technology can be easily used. ・The success rate of process innovation is high.
Appropriability	・A high level of technology is required for product development. ・Efforts of innovation and its protection are important. ・High appropriability.	・Technology innovation is partially required in the development of fuel. ・Process innovation to lower production costs is most important. ・Relatively low appropriability.
Cumulativeness	・Product improvements are carried out based on the accumulation of innovation capabilities. ・More superior cumulative innovation capabilities allow for an advantage in developing future products.	・There is little variety in the types of products and the process technology is of a low level. ・However, the use of accumulated technologies is high.
Knowledge base	・Specialized knowledge corresponding to product characteristics is required.	・General knowledge about fuel production is required.
Major products	・Solar energy, wind energy, fuel cells, etc.	・Biofuels, etc

Ordinarily, a firm's growth rate can be measured according to the growth rates of sales, assets, and number of employees. In the case of the growth rate of assets, tangible assets cannot be a proper proxy for growth in industries where intangible assets play an important role in firm growth. Meanwhile, the growth rate of the number of employees does not require a deflator; this is an advantage. The disadvantage of using the number of employees, however, is that there are too many missing data in the Thomson database, and this number tends to be stagnant for long periods in some firms. In contrast, the growth rate of sales can accurately reflect the long- and short-term changes of firms, and is a commonly used indicator (Coad and Holzl, 2010). Accordingly, this study used the growth rate of sales for a two-year period beginning with the start of the business.

Table 8 explains the variables used in this research.

For the dependent variables, the sales growth rates of firms were used in the form of natural logarithmic function.

Regarding the main independent variables, firms with *do novo* characteristics have "1" as the de_novo variable, and the firms with *de alio* characteristics have a "0" for the de_novo variable. We used the two types of dummy variable that distinguish between *de alio* and *de novo* firms, "equipment subsector," and "fuel subsector," as independent variables. The dummy variable of equipment subsector is "1." Our control variables were age and the profit_ratio (=profit/sales), and R&D intensity. ln_sales is an indicator of the relevance of firm size, and R&D intensity shows how much the companies invested in the industry and how active they were in R&D. We assume that a one-year time lag exists between a firm's growth and the control variables.

All monetary figures were converted to constant 2005 dollars by the U.S. GDP deflator.

Table 8. Variables definition in the *de alio* and *de novo* studies

Key variables	Definition
y	Firm's sales growth rate, y_{it}= lnS_t-lnS_{t-1}, (S_t: sales of the applicable year, S_{t-1}: sales of the previous year)
de_novo	Dummy variable for d*e novo*(de novo=1)
subsector	Dummy variable for the equipment industry (Equipment subsector=1)
de_novo x ln_sales	Interaction term of *de novo* and ln (sales)
age	Age of a firm
profit_ratio	Ratio of profits earned to sales (profit/sales)
ln(sales)	Logarithm of firm *i*'s sales in year *t*
rnd_intensity (t-1)	Company *i*'s R&D intensity(= R&D/sales) in year *t*–1

The regression model is expressed as follows.

$$\mathrm{y}_{it} = \alpha_{it} + \beta_1(de\_novo)_i + \beta_2(subsector)_i + \beta_3(de\ novo\ \mathrm{x}\ln(sales))_{it}$$
$$+ \beta_4(age)_{it} + \beta_5(profit\_ratio)_{it} + \beta_6\ln(sales)_{it} + \beta_7(R\&D\ int)_{it-1} + e_{it} \quad \text{Eq.(13)}$$

Eq. (13) can be regressed by panel models such as fixed and random effect models. α_i could be regarded as a random variable that is not uncorrelated with any covariates if we can guarantee a random selection process from the population. And then, the random effect model is more appropriate than the fixed effect model. On the other hand, the fixed effect model considers α_i as a parameter rather than a random variable; thus, β_1 and β_2 cannot be estimated.

Therefore, the random effect model is usually used to examine the effect of firm-specific variables (Clarke et al., 2010). This paper also aims to identify whether *de alio* or *de novo* firms achieve faster sales growth when entering the market and how long this effect lasts in the new and renewable energy industries. In this type of research where a dummy variable is a main independent variable, this model is useful as it identifies the coefficients of dummy variables that are omitted in the analysis with the fixed effect model and verifies their significance. Thus, the random effect model was adopted.

4.4 Empirical analysis

4.4.1 Results of descriptive statistical analysis

Because the entry month of each firm can be different, even within the same cohort, sales in the entry year cannot be considered annual sales. Furthermore, there are typically many missing values in the entrance year. Alternatively, we assume the year after entrance as the first year.

As shown in Table 9, after the 1990s, the alternative sector of the Thomson Reuters Datastream included 292 firms, of which 154 firms were *de alio* and 138 were *de novo*. *De alio* firms make up a larger proportion than *de novo* firms in the new and renewable energy industries. When subdividing new and renewable energy industries into equipment and fuel subsectors, the results show that while the number of *de alio* and *de novo* firms was almost the same in the equipment subsector, the entry proportion of *de alio* firms is higher in the fuel subsector. As mentioned in section 4.2, initial capital investment and manufacturing process are considered more important in the fuel subsector than the equipment subsector, and *de alio* firms enter the fuel subsector more frequently than *de novo* firms.

The actual panel data analysis was performed with the 292 firms that entered the industry from 1990 to 2010. Figure 3 shows that the number of entrants began to increase in the late 1990s. Subsequently, there was a gradual decline after the peak in 2006. Table 8 provides descriptive statistics from 1991 to 2010, which are graphically presented in

Figure 4. As Table 10 and Figure 4 show, the average sales and average total assets gradually fell in the late 1990s and changed their courses to a subsequent rise after 2000. In consideration of the increase in the number of entering industries after 2000, it can be concluded that the new and renewable energy industries were in the growing stage in 2000.

Table 9. The number of *de alio* and *de novo* firms in the new and renewable energy industry

	Fuel subsector	Equipment subsector	Total
De alio	62 (21.2)	92 (31.5)	154 (52.7)
De novo	44 (15.1)	94 (32.2)	138 (47.3)
Total	106 (36.3)	186 (63.7)	292 (100)

Numbers in parentheses are frequency cell percentage.

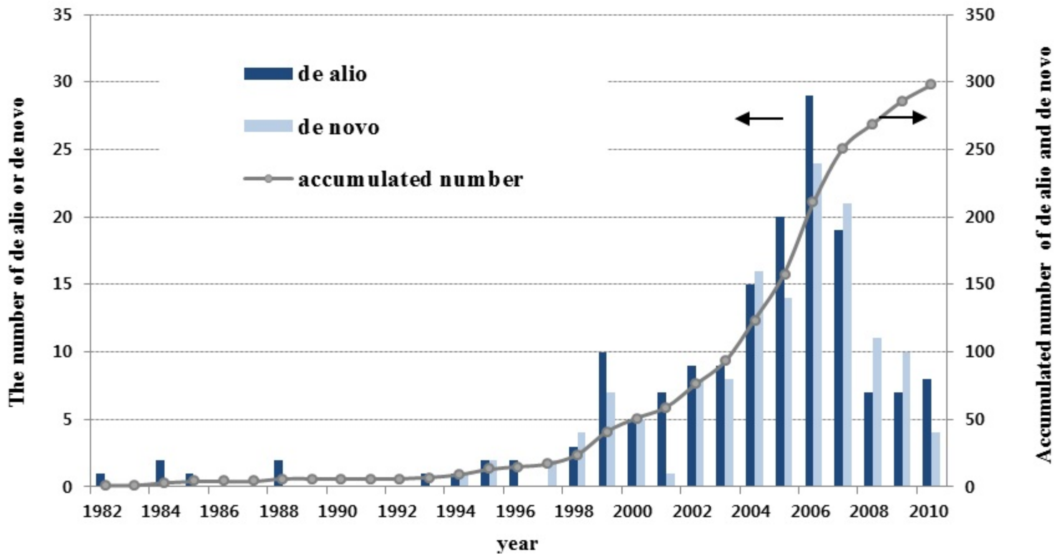

Figure 3. Annual number of entry firms in the new and renewable industry

Table 10. Observations and median of key variables by year in the new and renewable energy industry

Year	Statics	Sales growth	Sales ($millions)	CAPEX ($millions)	R&D intensity
1991	no. of obs.	6	6	5	6
	median	0.06	183.42	4.92	0.02
1992	no. of obs.	6	6	5	6
	median	0.14	213.81	7.95	0.02
1993	no. of obs.	5	6	5	6
	median	-0.15	124.52	3.97	0.00
1994	no. of obs.	6	8	7	8
	median	0.08	90.08	3.99	0.00
1995	no. of obs.	8	11	10	11
	median	0.18	48.97	3.01	0.00
1996	no. of obs.	12	13	12	13
	median	0.11	74.25	3.43	0.00
1997	no. of obs.	14	16	13	15
	median	-0.04	39.69	2.25	0.00
1998	no. of obs.	16	23	22	22
	median	-0.11	15.70	1.20	0.00
1999	no. of obs.	22	38	35	38
	median	0.07	7.88	0.38	0.00
2000	no. of obs.	40	50	49	47
	median	0.06	5.63	0.17	0.00
2001	no. of obs.	48	56	55	54
	median	0.00	6.86	0.64	0.00
2002	no. of obs.	52	68	68	67
	median	0.06	4.59	0.34	0.00
2003	no. of obs.	71	86	85	83
	median	0.10	4.41	0.47	0.00
2004	no. of obs.	85	113	109	103
	median	0.01	3.69	0.21	0.00
2005	no. of obs.	108	136	135	125
	median	0.09	6.28	0.30	0.00
2006	no. of obs.	141	186	182	174
	median	0.21	7.29	0.31	0.00
2007	no. of obs.	183	219	217	204
	median	0.31	8.19	0.78	0.00
2008	no. of obs.	229	244	244	228
	median	0.30	10.18	1.36	0.00
2009	no. of obs.	231	252	251	237
	median	0.24	12.71	2.43	0.00
2010	no. of obs.	257	274	273	259
	median	-0.02	11.77	1.17	0.00
Total	no. of obs.	1540	1811	1782	1706
	median	0.10	8.58	0.79	0.00

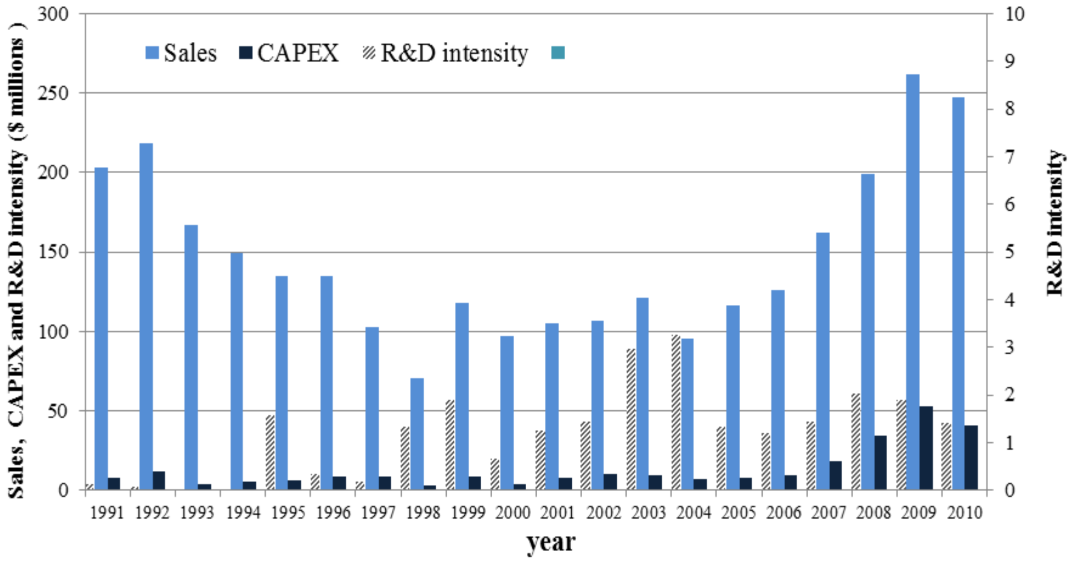

Figure 4. Annual averages of sales, CAPEX, and R&D intensity of *de alio* and *de novo* firms

Table 11 shows the averages of sales, CAPEX, and R&D intensity for *de alio* and *de novo* firms. The values for the equipment subsector were higher than those for the fuel subsector. As equipment subsector firms work primarily in the field of manufacturing end products for solar power, wind power, and fuel cells, it could be concluded that investments in new facilities and R&D are necessary.

The results show that *de alio* firms have higher sales for both subsectors (equipment, fuel). While *de alio* firms have higher CAPEX in the equipment subsector, *de novo* firms have these advantages in the fuel subsector. This result implies that the *de alio* firms that receive abundant R&Cs from their parent company maintain high sales. In the fuel subsector, which requires initial investment, the results seem to show that more investment is put into *de novo* firms. On the other hand, in the case of R&D intensity, *de novo* firms appeared to show consistently higher R&D intensity regardless of the subsectors; thus, it can be deduced that the technological innovations of *de novo* firms are actively progressing.

Table 11. The mean and standard deviations of sales, CAPEX, and R&D intensity

Variables	*de alio*		*de novo*		Total	
	Fuel	Equipment	Fuel	Equipment	Fuel	Equipment
Sales	45.8	330.3	31.7	111.9	39.9	230.7
$millions	(115.4)	(1209.2)	(137.4)	(359.7)	(125.1)	(930.5)
CAPEX	8.0	38.4	13.3	22.1	10.2	31.0
$millions	(21.4)	(153.6)	(44.8)	(78.8)	(33.1)	(125.1)
R&D	0.6	1.0	3.3	2.8	1.7	1.8
intensity	(4.1)	(7.6)	(14.3)	(11.7)	(9.6)	(9.6)

Numbers in parentheses are standard deviation.

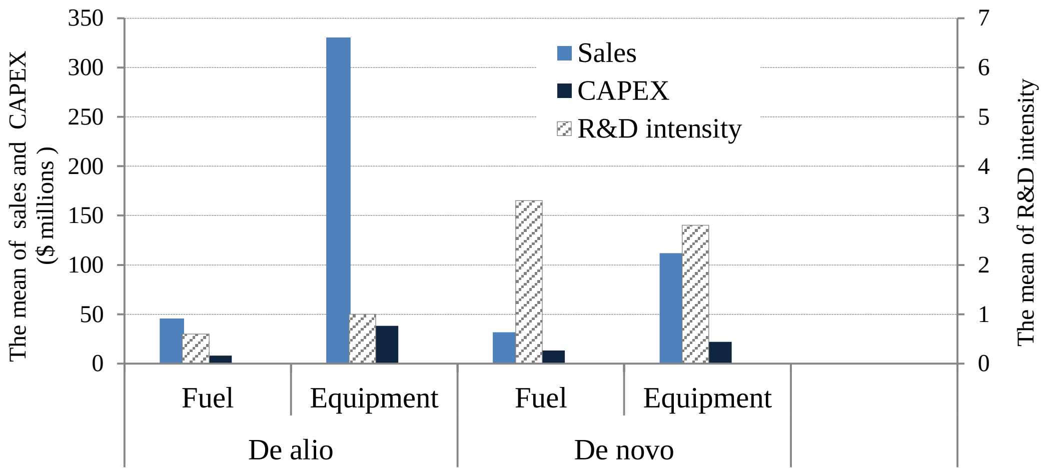

Figure 5. The mean of sales, CAPEX and R&D intensity of *de alio* and *de novo* firms

As shown above, the new and renewable energy industry entered its growing stage in the 2000s, and the equipment subsector, which primarily involves manufacturing and equipment, shows relatively higher average sales, CAPEX, and R&D intensity than the fuel subsector. Thus, these results imply that the equipment subsector leads the new and renewable energy industry. Additionally, *de novo* is a major entry mode in the manufacturing and equipment industries, which have a high appropriability of technology.

4.4.2 **Results of regression analysis**

Table 12 shows that the number of observed targets, average value, standard deviation and the correlation matrix for main variables and main dummy variables. Except for the correlation between de_novo and the interaction variables, it was verified that the crossed correlation among variables is not very high.

Table 13 shows the effects of the *de alio* and *de novo* modes on sales growth rates after market entry.

In our results, the age variable shows a negative sign with firms below the sixth year after entrance. The logarithm variable of sales (ln_sales), a proxy for firm size, has a statistically significant negative value with firms younger than three years but a statistically significant positive value with four-to-six-year-old firms. It is generally acknowledged that firm age and size have an inverse relationship with firm growth. Other studies maintain that the initial negative relationship turns positive after a time interval (Arne and Mulu, 2007). We can explain the early inverse relationship by observing that small or young entrants face several limitations when starting a business in the new and renewable energy industry. A high level of uncertainty arising from oil price fluctuations surrounds this early stage industry. However, neither age nor size has a significant relationship with firm growth for firms over the seventh year after entrance. This indicates that, in the new and renewable energy industry (unlike in existing industries), age and size play only a small role in firm growth. On the other hand, the profit ratio has statistically insignificant values for firms younger than three years but statistically significant positive values for firms older than four years. That R&D intensity boosts firm growth is consistent with the literature (Coad, 2009).

Model 1 show that the de_novo dummy variable is statistically significant and has a negative coefficient until the third year after market entrance. Thus, the sales growth of *de alio* firms is higher than that of *de novo* firms because *de alio* firms enter the market with the full resources, capital, and human resources support of the parent company (Mitchell, 1994); thus, such firms have no problem entering a new industry. In addition, the initial growth appears to be higher because of the brand value prior to entry, which gives them an immediate large market share (Klepper and Simons, 2000). However, Model 2 and Model 3 show that de_novo dummy variable is statistically insignificant, which implies that this *de alio* effect disappears after the fourth year of market entrance, suggesting that the effect of the R&Cs advantageously applied to *de alio* firms decreased over time because of the firms' rigidity and inertia. Models 1 to 3 also show that the interaction variable of the *de novo* mode and sales has a statistically significant and positive coefficient until the third year after market entrance, implying that *de novo* firms achieve higher growth rates as their sales increase. These results lead us to expect that large *de novo* firms are likely to catch up to *de alio* firms over time. Thus, as time passes, *de novo* firms accumulate more resources and competencies, which may erase any distinction between *de alio* and *de novo* firms.

Models 2 to 3 show that the growth rates in the equipment and fuel subsectors showed significant results after the fourth year of market entrance. This means that the industrial characteristics in the new and renewable energy industry are likely to have an important influence on firms' growth patterns. Meanwhile, R&D intensity has a positive effect on sales growth, indicating that R&D investment affects firm growth.

Innovation in products, process, and techniques through R&D investment help firms secure competitive advantages and eventually achieve firm growth. This is why researchers frequently use an R&D variable in studies on firm growth. Widely used R&D variables include R&D stock, R&D expenditure, and R&D intensity. R&D capital stock is a good measure of growth but is limited to short-time series analysis. Therefore, we use R&D intensity as a proxy for R&D capital stock in the firm growth equation. Since the total R&D expenditures reveal a very strong correlation with sales, we use R&D intensity instead of total R&D expenditures. Many studies have investigated the influences of R&D intensity on firm growth. Most argue that the initial R&D intensity shows a positive correlation with employment growth (Hall, 1987), while other researchers maintain that R&D activities have nothing to do with firm growth. Brouwer et al. (1993) observe that

R&D intensity has an inverse relationship with employment growth (Brouwer et al., 1993). Despite the contrasting views on the relationship between R&D intensity and firm growth, it is no exaggeration to say that a great many researchers have used R&D intensity as an estimate of innovation expenditures and innovation outputs to measure firms' innovation activities.

As indicated in Table 11 and Figure 5, *de novo* firms have higher R&D intensity than *de alio* firms, likely an indication that *de novo* firms more actively engage in innovation activities. According to the regression analysis shown in Table 13, *de novo* firms show lower growth rates than *de alio* firms in the early years, until three years after entry, because the former lack inherited R&Cs (see Model 1). This phenomenon becomes insignificant, as demonstrated in Model 2 and Model 3. The attributes of *de alio* and *de novo* firms affect short-term performance, but the influences fade over the long term. Recent studies have found that the survival rates of *de novo* and *de alio* firms change over time and that firms' *de alio* and *de novo* features disappear over the long term (Chen et al., 2012). Out results show that the gap between the two closes more quickly than the current literature suggests.

Regarding the interaction variable of de_novo and ln(sales) (de_novo x ln_sales), large-scale *de novo* firms show high growth rates in the early years; however, the advantages arising from their large size weaken after four years. On the other hand, the coefficients of d_subsector indicate that the subsector influences firms' growth rates even after the early years, while firms in the fuel subsector show higher growth rates than their counterparts in the equipment subsector. In terms of sales and R&D investments, the equipment subsector shows higher average growth rates than the fuel subsector does. On the contrary, equipment subsector firms, such as wind power and solar energy producers, have relatively vulnerable factors for firm growth. They should fight a price war against the manufacturers of fossil fuels, whose prices are related to fluctuating oil prices. Amid the uncertainty of fluctuating oil prices, they still have a long way to go before they establish a stable production capacity and commercialize the technology, as well as breaking the high technological barrier (Johnstone et al., 2010; Schilling and Esmundo, 2009).

Our results indicate that the effect of a firm's innate features on the sales growth rate weakens as time passes. Similar results have been found in the literature (Khessina and Carroll, 2008), which reveals that the exit rate of *de novo* firms slows as time passes and eventually tends to converge with the survival rate of *de alio* firms. However, our study can be differentiated from Khessina and Carroll (2008), as it has not only determined whether the difference between *de alio* and *de novo* exists but also identified its decreasing pattern concretely.

Table 12. Descriptive statistics for variables of *de alio* and *de novo* firm studies

		Obs	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.
1.	y	1540	0.547	2.167	1.000							
2.	de_novo	1827	0.441	0.497	0.016	1.000						
3.	d_subsector	1827	0.655	0.475	-0.036	0.027	1.000					
4.	de_novo x ln_sales	1667	3.266	4.673	0.050	0.940	0.052	1.000				
5.	age	1827	4.290	4.329	-0.201	-0.167	0.031	-0.142	1.000			
6.	ln_sales	1347	8.790	3.670	-0.405	-0.114	0.207	0.071	0.283	1.000		
7.	rnd_int (t-1)	1447	1.742	9.392	0.174	0.070	0.039	-0.008	-0.001	-0.284	1.000	
8.	profit/sales	1482	-7.963	38.017	0.133	-0.063	0.078	0.062	0.022	0.317	-0.224	1.000

Table 13. Regression results of *de alio* and *de novo* studies

Dependent Variables : sales growth	Model 1 ($\leq 3^{rd}$ year) coef. (std. err.)	Model 2 ($4^{th} \sim 6^{th}$ year) coef. (std. err.)	Model 3 ($\geq 7^{th}$ year) coef. (std. err.)
de_novo (de novo=1)	-2.206**	0.983	0.106
	(0.914)	(0.916)	(1.152)
d_subsector (equipment=1)	-0.478	-1.062***	-0.722**
	(0.339)	(0.338)	(0.313)
de_novo X ln_sales	0.237***	-0.117	-0.009
	(0.086)	(0.084)	(0.099)
age	-0.647***	-0.269***	-0.002
	(0.178)	(0.082)	(0.019)
profit / sales	0.006	0.008**	0.008*
	(0.006)	(0.003)	(0.004)
ln_sales	-0.137**	0.134**	0.067
	(0.062)	(0.067)	(0.065)
rnd_intensity (t-1)	0.061***	0.050***	0.047***
	(0.018)	(0.019)	(0.008)
year dummy		included	
constant	3.523***	1.214	-0.089
	(0.853)	(0.780)	(0.888)
R2 overall	0.14	0.09	0.08
Observations	363	484	414
Number of firms	209	207	101

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

We also conducted a quantile regression analysis[6] to examine the relationship between the entry modes and growth rates. We divided the entrants into nine quantiles according to growth rates, a division that clearly shows how the effects of the independent variables of entry modes on growth rates differ according to the entrants' age.

As shown in Figure 6, the coefficient for *de novo* firms under three shows a sharper decline in the higher growth groups. The *de novo* firms in the higher growth groups exhibit lower growth rates, another indication that the effects of *de alio* firms become stronger in the higher growth groups. We detected a similar pattern for four-to-six-year-old *de novo* and those over the seventh year of entrance. The effect of *de novo* firms on growth rates shows consistently low negative values up to the 7th quantile, and the value turns positive after the 8th quantile.

We interpret these results as follows.

For firms under the third year of entrance, the *de novo* effect on growth rates varies depending on the group.

For four-to-six-year-old firms and firms over seventh year of entrance, the effect disappears but drastically turns positive only in groups higher than the 8th quantile.

As indicated in Table 13, the *de novo* effect wears off over time. In the high-growth

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[6] The quantile regression model can be written as (Koenker and Bassett, 1978):
$y_i = x_i^{'}\beta_\theta + u_{\theta i}$, $\mathrm{Q}_\theta(y_i \mid x_i) = x_i^{'}\beta_\theta$ where y_i is the dependent variable, x_i the vector of independent variables. β_θ is the vector of the parameters to be estimated for a given value of the quantiles θ. $\mathrm{Q}_\theta(y_i \mid x_i)$ is the θ th quantile of y_i given x_i.

groups, the growth rate gaps between *de alio* and *de novo* firms narrow more significantly over time than in the low-growth groups.

For both *de alio* and *de novo* firms, the effect of the firm's innate features on sales and growth rate weakens over time. Similar results have been found in the literature (Khessina and Carroll, 2008), revealing that the exit rate of *de novo* firms slows as time passes and eventually tends to converge with the survival rate of *de alio* firms. However, this study can be differentiated from Khessina and Carroll (2008) because we have not only examined whether the difference between *de alio* and *de novo* exists but also identified its decreasing pattern.

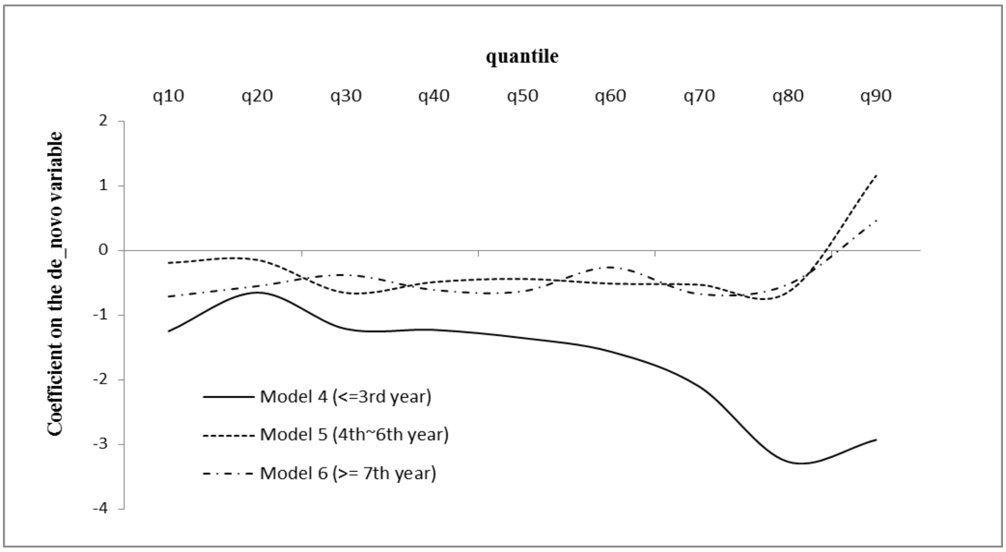

Figure 6. Quantile regression results on sales growth of *de alio* and *de novo* firms[7]

[7] Since the coefficients are not statistically significant, the results table was not included in in the paper. Instead, interpretations of the results table are provided in the appendix of this thesis.

4.5 Summary

Several important conclusions can be drawn from Chapter Four.

First, companies' sales averages gradually declined in the late 1990s and then drastically increased after 2000 in the new and renewable energy industry. Given the increase in the number of entrants after 2000, it can be concluded that the new and renewable energy industry entered a growth stage at that time. Sales in the equipment subsector were found to be higher than those in the fuel subsector; the equipment subsector clearly deals with the manufacturing of end products, including important products used in solar energy, wind energy, and fuel cells.

Second, *de alio* firms have higher average sales than *de novo* firms, while *de novo* firms tend to have a higher R&D intensity than *de alio* firms, which may indicate that *de alio* firms start with more resources and higher competence levels while *de novo* companies start with a higher potential for technology innovation.

Third, although *de alio* firms with ample resources show higher growth rates, this gradually decreases over time. Moreover, four years after market entrance, the difference between the sales and growth rates of *de alio* and *de novo* firms decreases because the systematic characteristics of *de alio* and *de novo* firms fade and eventually disappear over time.

Fourth, *de novo* firms achieve higher growth rates as their sales increase, leading us to expect that large *de novo* firms are likely to catch up to *de alio* firms over time.

As firms tend to grow over time, the third and fourth conclusions imply that the difference between *de alio* and *de novo* firms in terms of sales becomes (ceteris paribus) diluted over time.

This study has established that the characteristics of *de novo* and *de alio* firms in the automobile and electronic sectors as well as other growing sectors that have been analyzed in previous studies can be expanded to include the new and renewable energy sector. Therefore, *de alio* firms that have received R&Cs from their parent companies have a market competition advantage against *de novo* firms that undertake the challenge of new environments through technology innovation.

Studies in this field have been limited to examining firms' long-term survival rates. By contrast, this study has analyzed the growth rates of new firms, which may be a direct and immediate cause of firms' survival. This investigation explored short-term firm growth in growing industries using the *de alio* and *de novo* dichotomy, finding that the effects of *de alio* and *de novo* firms fade over time and that these innate conditions begin to conflict with the R&Cs firms acquire as they grow. Thus, this study indicates that, although R&Cs received from parent companies prove to be advantageous in the early stages of a company, they eventually expire, and new R&Cs must be secured.

This study has certain limitations. It does not examine the causes of the changes in the *de alio* and *de novo* effects. Future research should conduct an in-depth analysis on why the effects of *de alio* firms' R&Cs weaken over time. In addition, studying industries other than the new and renewable energy industry will allow comparative analyses of the general growth patterns of *de alio* and *de novo* firms from the sectoral regime perspective.

Chapter 5. The Effects of Evolution of Resources and Capabilities on Firm Growth

5.1 Introduction

New firms enter the market with different motives and initial statuses in terms of their internal/external conditions, yet the goals remain the same: stable settlement, economic growth, and sustainable survival in the market. However, not all firms can be successful in this competitive society, and even currently successful firms cannot predict their own futures in an uncertain market environment. Extensive evidence demonstrates that few new firms achieve success; for example, according to Santarelli and Vivarelli (2007), more than half of the newly established firms disappear within five years of establishment.

Many theories and verified results have been presented concerning the environments that firms are able to grow in and the conditions that enable firms to survive. However, in this dynamic situation, where industrial structures, market environments, characteristics of firms, and related factors are continuously changing, management theories and realities for firms continue to change accordingly.

Organizational ecology theory, discussed in Chapter Three, explains the survival and growth of firms by stating that the environment selects firms. Despite firms' strategic responses and adaptive efforts, the environment's influence is difficult to avoid. Structural inertia within firms prevents them from responding quickly to the rapidly changing environment; thus, firms customized to the existing or previous environment eventually disappear, and firms with strategies and structures fit for the new environment start to appear (Hannan and Carroll, 1992; Hannan and Freeman, 1984).

Resource-based theory explains that the resources a firm holds determine its strategies and competitiveness. The firm's capabilities, on the other hand, provide the fundamental drivers for growth and survival. The theory argues that as firms secure R&Cs that are difficult to gain and copy, sustainable competitive advantages are created, contributing to the firms' growth and survival (Amit and Schoemaker, 1993; Barney, 1991; Hamel and Prahalad, 1990; Wernerfelt, 1984).

The evolutionary theory refutes the initial organizational ecology theory. In contrast to the existing argument of firms being incapable of adapting to environmental changes, it explains that in the process of changing and adapting themselves, firms expand their knowledge and capacities relevant to the environment they operate in. The differences in firms' abilities to acquire new routines and their learning capabilities are the main factors that affect their evolution. Therefore, evolutionary theory maintains that firms that are able to progress through the exploitation of the best alternatives from their existing achievements and the exploration for new solutions in an uncertain future can be guaranteed to grow and survive (March, 1991; Nelson and Winter, 1982).

It is true that it is difficult to generalize the causes for the success or survival of newly established firms due to numerous complex factors responsible for growth. New firms are too inexperienced to establish internal R&Cs and do not have enough external recognition to induce external cooperation, and thus have a "liability of newness." Due to these reasons, organizational ecology argues that new firms tend to disappear and do not have the structural inertia to adapt to the environment (Freeman et al., 1983). There have been many studies on the characteristics and effects of structural inertia; however, few detail when the inertia starts to occur and what causes the change. The weakness of organizational ecology theory is that since it pays attention to the replaced firms through differential selection by the environment and considers the yield rate and extinction rate of demographic vital rates as major dependent variables. Therefore, it requires long-term observation and is difficult to use as a strategic management theory for predicting and valuing the mid- and long-term growth of firms.

The theory of firm evolution deals with the areas that cannot be explained clearly by the earlier firm growth theories. In the case of a new firm, which has insufficient initial experience, its path dependent knowledge base (Nelson and Winter, 1982) is initiated. Therefore, it looks at not only the (natural) R&Cs inherited prior to the firm's entrance in the market, but also at how nurtured R&Cs are acquired through experiences and efforts as well as how these newly acquired R&Cs impact the firm's growth. However, empirical researches on how these R&Cs influence the growth rate of firms and how long these effects last are few in number, and no clear conclusions have been drawn.

This point is significant from a management strategy perspective; nevertheless, few in-depth researches have been performed on the dynamic evolutionary processes of acquired R&Cs.

The eventual goal of management strategies is to locate the causes of differences in management performance or growth rates among firms. So far, their fundamental causes have been considered to be the internal R&Cs that the firms already have. It is not too difficult to understand that R&Cs create differences in firms’ future performances; however, it is difficult to verify this with empirical research, which requires their direct measurement. Furthermore, with regards to R&Cs, there have been mixed results from empirical studies as there is ambiguity as to whether they were present in the original environments of the new firms or have evolved and accumulated during business activities. Very few empirical results exist concerning which resources, both inherited and nurtured, are more effective to the future growth of a firm.

In an effort to understand the creation and evolution of R&Cs dynamically, the present research compares new firms’ pre-entry experiences immediately before establishment and the intensities of the experiences after the establishment as well as conducting an empirical analysis on their impact on the long-term growth of firms. The purpose is to understand the initial creation process of R&Cs and their effects on the future growth dynamically, which has not been clear in various other empirical researches.

In addition, the present research assumes that the initial structural inertia of a new firm is due to R&Cs from the pre-entry experience and nurtured resources and capacities acquired from the post-entry effort. Depending on the types of post-entry efforts and the degree of efforts, the state and sustainability of effects is determined. Depending on the initial structural inertia, strategic decisions on the size of business and the amount of investment in production facilities or R&D might be different.

In this chapter, Section 5.1 reviews existing research on the respective impacts of nature and nurture R&Cs on the growth of firms. Section 5.3 explains the results of the empirical analysis based on the research design and the models suggested in Section 5.2, Finally, a summary of the findings is presented in Section 5.4.

5.2 Previous studies

5.2.1 Firm growth

In discussing the growth of a sizable firm that already operates in business, the frequently used management strategic viewpoint is R&Cs. The abundant resources that a firm owns and its differentiated core capabilities serve as leverage to lower the market risks and exploit new opportunities. Capital, technologies, organizational structure, experiential knowledge and other R&Cs continue to be accumulated and transferred and are the sources for firms to grow continuously (Teece and Pisano, 1994).

R&Cs are not always helpful to the growth of a firm. The firm adequately equipped with these can possibly implement progressive innovation through the organizational routine, but firms lacking in organizational flexibility due to the inertia do not adapt to the rapidly changing environment and thus cannot promptly respond with progressive and innovative activities (Christensen *et al.*, 2004).

New firms consist of diversified firms entering the market with sizable R&Cs inherited from their parent firms, spin-off firms (*de alio*), and start-up firms (*de novo*) entering the market without fundamental R&Cs but solely with dynamic innovative capabilities.

Core capability is a frequently addressed topic when discussing the growth of a new firm or a firm in the technology-intensive industry. New firms entering the market do not have inherited R&Cs and thus are not influenced by existing methods. In addition, in new industries, since new firms do not have information on existing firms, they tend to go forward solely with trust in their core technologies. Also, their small size and flexibility enables them to promptly respond to the changes in the environment (Hannan and Freeman, 1984; Haveman, 1992). New firms tend to be ahead of the prevalent technology in the beginning, but since their accumulated R&Cs are insufficient and their position in the industry, brand value and experience are insubstantial, they might fall to failure (Bruderl *et al.*, 1992).

Therefore, in researching the growth pattern of new firms, R&Cs are important bases for making decisions.

5.2.2 **Previous studies on pre-entry experience**

Several difficulties are found in analyzing the impacts of R&Cs on the firm growth rate. First, it is difficult to detect when R&Cs start to be generated and the impact of the acquired R&Cs tends to change over time. In addition, R&Cs generated from business activities are a mixture of several factors. Thus, it is difficult to separate and analyze the effects of particular R&Cs. Various researches have been conducted on *de alio* and *de novo* firms by excluding the R&Cs gained during the business activities and focusing on the R&Cs generated based solely on their pre-entry experience (Carroll et al., 1996; Khessina and Carroll, 2008).

De alio and *de novo* firms enter the market at the same time. However, depending on their pre-entry experiences and the types of these experiences, they start with different organizational types and different patterns of innovative activities (Khessina and Carroll, 2008) or marketability (Carroll *et al.*, 1996) are revealed. In the case of a *de alio* firm, which has pre-entry experience, since it receives sufficient support in terms of resources, capital and manpower from the existing firm (Mitchell, 1994), regardless of its success, it can proceed with business (Levinthal, 1991). The resources, capabilities and brand value received from the previous firm help raise market share (Klepper and Simons, 2000) and serve as an advantage for the *de alio* firm's long survival in the market (De Figueiredo and Kyle, 2006). The stable organization system and manufacturing routine increase the credibility of products leading to higher possibility of success (Hannan and Freeman, 1984). In addition, experiences in the market enable them to promote their products more effectively (Nerkar and Roberts, 2004) and the new products relevant to the reputation of their parent-firms have favorable position in terms of advertisement when released (Podolny, 1994; Swanson, 2002).

On the other hand, a *de novo* firm without the pre-entry experience, does not have

R&Cs compared to a *de alio* firm, but various empirical researches prove that it has the advantages of flexibility and prompt responses to changes in the environment (Carroll et al., 1996; Hannan et al., 1998; Mitchell, 1994). In particular, *de novo* firm tend to be technologically advanced and release innovative products (Khessina, 2003; Khessina and Carroll, 2008) and innovative companies survive longer in the market (Stavins, 1995).

Since a *de novo* firm is naturally free from the technological trace that a parent firm holds, it has an inborn tendency to try innovative technologies. It makes an effort to acquire the best technologies and tends to have a business structure fit for competition.

A common phenomenon found in *de alio* and *de novo* firms is that organizational characteristics are changing with time. For *de alio* firms, R&Cs favorable for survival rate generate side effects past the initial period, such as problems of organizational rigidity and inertia. For *de novo* firms, the flexibility to change with the environment helps gain R&Cs as time goes by and accordingly, the exit speed of products becomes longer and eventually it catches up with the survival rates of *de alio* products (Khessina and Carroll, 2008). Surely, after a certain period of time, *de novo* also finds itself in difficulties with inertia, the same as *de alio* (Carroll *et al.*, 1996).

The concepts of *de alio* and *de novo* explain the effects of the pre-entry experience adequately. The shortcomings are that these concepts have been used to analyze survival or extinction and not many empirical analyses have been conducted on the effects of these concepts on the long-term performance of a firm. In addition, it is rare to locate researches that examine how the characteristics of *de alio* and *de novo* firms change when the new nurture experience is added after entrance to the market to the nature R&Cs dividing *de alio* and *de novo* firms.

5.2.3 **Previous studies on post-entry efforts**

The impact of business activities and experiences on the performance of a firm has been researched. However, this research did not examine post-entry effort specifically, but multiple aspects of an entire range of business activities.

A firm's management activities lead to the firm's learning by doing (Arrow, 1962), and its strategies, organizational operation, investment in R&D, acquisition of external knowledge, alliance, M&A activities, and related factors have direct impacts on its performance. However, most researches are limited to the analysis of their short-term impacts on business activities and performance, and are not applicable for the analysis of long-term performances. This is especially true of researches on the impact of the firm's initial experience on long-term business performance, which have not gained much attention from the academia. Some limited researches on new firms or entrepreneurship dealt with analyses of the initial activities of firms (Aldrich, 1999; Costello, 1996; Cyert and March, 1992; Deakins and Freel, 1998; Hambrick and Schecter, 1983; Hugo and Garnsey, 2005; Kim et al., 2009).

The researches dealing with companies' initial business activities and experiences analyze how initial experiences have impacted their survival and short-term performance. Theoretical and positive analyses are available on the impact of experiences, such as operating experience (Kim et al., 2009), problem solving experience (Hugo and Garnsey, 2005), success experience (Aldrich, 1999; Cyert and March, 1992) and recovery experience (Hambrick and Schecter, 1983). The Deakins and Freel's research (1998) explains that the initial activities of a company affect its future organizational learning and the formation of its routine. In the experiences and activities that a business organization undergoes, the company learns via trial-and-error and this learning is internalized as the company's own problem-solving method, response to the changes in the market environment and culture, and becomes a routine (Deakins and Freel, 1998).

The routine of an organization refers to its generalized organizational activities and is represented as the organizational culture. Routine is based on the research of evolutionary economics (Levitt and March, 1988; Nelson and Winter, 1982). The routine internalized in a firm enables the effective utilization of the limited capacity (Louis and Sutton, 1991; Simon and Barnard, 1976; Winter, 1985), and is used as a strategic tool to respond to the uncertain environment (March and Simon, 1958; Weiss and Ilgen, 1985). The routine provides safety to the organizational operation, affects the operation of a company (Hodgson, 1997) and wide range of activities such as adjustment and cooperation among stakeholders inside the organization (March and Olsen, 1989; Nelson and Winter, 1982), and makes an impact on the performance of the firm.

The initial experiences and activities of a firm become its routine through the learning process, and in the long term (Deakins and Freel, 1998), these have an impact on the firm's operation, culture and performance methods (Levitt and March, 1988).

Table 14. Details of pre-entry experience and post-entry effort

	Previous studies	Characteristics of the operation definition
Pre-entry experience	· The research on *de alio* and *de novo* firms has focused on the identifying of the effects of the pre-entry experience. *De alio* refers to a firm with pre-entry experience, *de novo* to one without.	· *De alio*[*)] – Exposed to less danger – Obtain a higher market share – Survive longer. – More effectively advertise their products · *De novo* – Flexible organization and prompt response to the change of environment – Innovative products
Post-entry efforts	· The firm learns through various experiences – Operating experience – Problem solving experience – Success experience – Recovering experience	· Growth rate is higher than the average growth rate of firms in the same industry, which considers that the strength of post-entry effort – Capital investment activities – R&D investment in manufacturing facilities – The individual worker′s experience due to the expansion of the labor force

* 1 for a firm affiliated with a corporate group and 0 for others in this chapter

5.3 Research design and analysis model

5.3.1 Research questions

The research examines the effects of R&Cs on the sales growth rate of firms. First, the research looks into the effects of the inherited R&Cs on the growth rate of sales. To understand this, the concepts of *de alio* and *de novo* are used. Since *de alio* firms have previous experiences, they are known to have more R&Cs while *de novo* firms have fewer inherited R&Cs while they have more flexibility and innovativeness.

The development of a *de novo* firm was difficult to interpret from the resource-based perspective. While it is rational to explain the high survival rate of a *de alio* firms as being due to relatively superior R&Cs, from an organization ecology perspective, it is inadequate to explain the successes of a *de novo* firm with its naturally insufficient R&Cs. Therefore, the current research intends to confirm that even if a *de novo* firm with insufficient natural R&Cs achieves post-entry efforts through flexible organization and innovative operation, the nurtured R&Cs that it is expected to create and the post-entry effort are as important to the firm's growth as pre-entry experience. Pre-entry knowledge and learning affect the growth and survival of new firms as much as pre-entry experience does (Dencker et al., 2009).

The question here is whether the effects of the pre-entry experience are direct or indirect and how long the effects last. However, it is difficult to reach a clear conclusion. Until recently, there have been mixed results on the effects of pre-entry experience in determining the characteristics of *de alio* and *de novo* firms. Thus, the following hypothesis is proposed:

Hypothesis 1: Pre-entry experience does not influence the long-term growth rate but only the short-term growth rate.

First, the research intends to confirm that the R&Cs inherited from the pre-entry experience influence the short-term growth rate of firms but not the long-term growth rate through Hypothesis 1. *De alio* and *de novo* firms are classified by their affiliation or lack thereof, respectively, to a corporate group, and this affiliation is used as a proxy variable in the present analysis.

Second, the research examines how nurtured R&Cs that the new firms gain from various efforts and experiences right after establishment influence firms' sales growth rates. To determine this, the activities and experiences of firms are measured for a certain period of time (4 years) after their establishment compared to other older firms in the same industry.

New firms will estimate their R&Cs with or without their pre-entry experience (Helfat and Lieberman, 2002), judge whether they fit into the new market environment or not, and eventually enter the market. Therefore, pre-entry experience can be the decisive factor affecting post-entry effort. Thus, classifying the effects of post-entry efforts and those of pre-entry experiences can be considered an important process. That is, post-entry effort should focus on the cultivating of R&Cs by a firm through the process of learning by doing over a certain period of time immediately following its establishment. It is important to study a firm's post-entry activities after it enters a new industry in order to gain a more complete understanding of its short and long-term performance.

Since the publication of March's (1991) pioneering article, the terms "exploration" and "exploitation" have emerged as the twin concepts underpinning organizational adaptation research (Gupta et al., 2006). Exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a "failure trap". In contrast, exploitation often leads to early success, which in turn reinforces further exploitation along the same trajectory, thereby creating a "success trap" (Gupta et al., 2006). However, March (1991) appeared very clear in his theorization that both exploration and exploitation are essential for long-run adaptation.

In order to adequately explain the effects of R&Cs acquired through post-entry effort, particularly long-term performance, it might be useful to distinguish post-entry effort by the differences in the type of exploration and exploitation or by the differences in effort over the short- and long-terms.

Operation management should be improved, while capital investment activities (Thompson, 2001), R&D investment in manufacturing facilities (Sinclair et al., 2000), and the individual worker's experience (Lazonick and Brush, 1985) due to the expansion of the labor force should be limited to the early activities of the firm. Generally, different capabilities favor either short-term performance or long-term performance; depending on the firm's focus, long-term performance can differ, with the specific firm's financial results providing important strategic implications as well as support for March's exploitation/exploration theory. Therefore, the following hypotheses are proposed:

Hypothesis 2a: Post-entry effort influences both short-term and long-term growth rates

Hypothesis 2b: Among post-entry efforts, tangible assets and employee efforts influence

short-term growth, while R&D intensity efforts influence long-term growth.

For Hypothesis 2a and 2b to be confirmed requires that the R&Cs of the firms, nurtured through post-entry efforts, influence both their long-term growth rate and their short-term growth rate and that their innovative activities are more influential on long-term performance than on short-term performance. To determine this, the research compares a new firm's average growth rates of initial investment activities and costs to those of other firms in the same industry and determines the intensity of the post-entry effort. The rate of R&D intensity refers to the applicable firm's innovative directivity; the rate of tangible assets refers to the firm's external growth directivity; and the rate of number of employees refers to the extension of products or firm size. All these are considered as post-entry efforts, and each is set as a main variable and its effect analyzed.

Hypotheses 2a and 2b entail that in the case of R&Cs nurtured from post-entry efforts, depending on the type of experience, the sales growth rate will change dynamically; different results are expected depending on whether the industry is high-tech or low-tech.

Pre-entry experience follows the passive learning model suggested by Jovanovic (1982), as explained before, since the firm is uncertain regarding the requirements of the environment or those required for entrance into the market. However, with the post-entry effort, the situation has changed. By acquiring different experiences, firms determine their own characteristics and accumulate R&Cs through competition or by predicting the future market environment; this can be said to follow the active learning model (Ericson and Pakes, 1995). In order to look at the synergy effect between active and passive learning, an additional interaction between pre-entry experience and post-entry efforts is reported. Recent research demonstrates that the durability of the effects of pre-entry experience can vary depending on the firm's post-entry effort (Thompson, 2005). Thus, it appears that a firm's pre-entry endowment of R&Cs will affect its ability to enact and adapt to subsequent change over the long term. Therefore, the following hypothesis is proposed:

Hypothesis 3: When post-entry efforts are combined with pre-entry experience, post-entry efforts may influence the long-term growth rate, based on their synergistic effect.

When the pre-entry experience and post-entry effort are closely related in terms of cause and effect, it is difficult to ascertain which one most determines the firm's growth rate. Therefore, it is necessary to confirm whether these two experiences are independent factors for growth rates and whether there are effects caused by their mutual operation. This research expected that there would be no effects from their mutual operation. To verify this, it was necessary to divide the R&Cs into nature and nurture and the sales growth rate into short-term and long-term, and to simultaneously analyze a reciprocal crossing item for each.

Therefore, the research used the triple difference (difference in difference in difference) method, which enables us to understand the result of the analysis for each as well as the quantitative significance. To determine whether a firm's growth rate is caused by pre-entry experience or post-entry effort, it is necessary to control interactional variables.

The triple difference method is very useful to understand the result of the research, as it can help determine the effects of pre-entry experience or post-entry effort on short-term or long-term results independently. This method also has the additional advantage of being able to comprehend the significance level of the coefficient of the interactional variable representing the effect of the reciprocal operation for each other on the results.

The concept models and hypotheses set in the research are as follows.

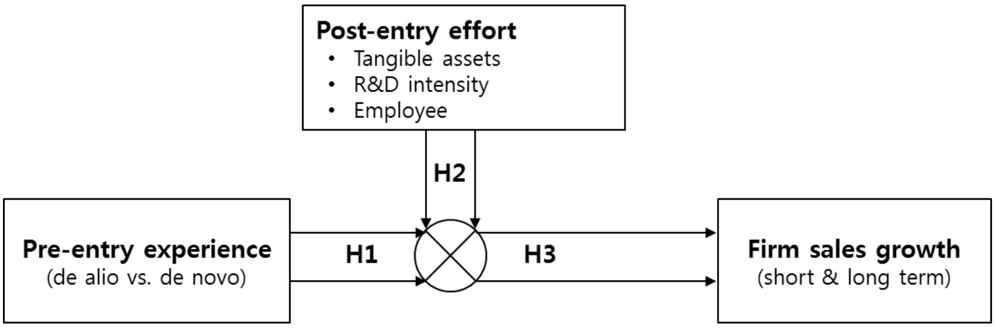

Figure 7. Conceptual hypothesis structure

The research shows that the results from H1 and H2 of Figure 7 represent that pre-entry experience and post-entry effort have independent impacts on the growth of firms, and the result (H3) from the interaction of H1 and H2 provides a crucial clue in understanding which experience, pre-entry experience or post-entry effort, has more impacts on long-term growth. Through this analysis, the research will verify whether the natural R&Cs, that new firms inherit without knowing and regardless of the market environment, have positive influences on their growth (Jovanovic, 1982), or the nurtured R&Cs gained through various activities upon entrance in the market are influential on the new firm's evolution to fit the environment (Pakes and Ericson, 1998).

5.3.2 **Data collection and analysis model**

The research used the 1985 to 2009 financial statements of NICE (National Information & Credit Evaluation lnc.) information service. These statements included information on the listed corporations in Korea, registered corporations in KOSDAQ (Korea Securities Dealers Automated Quotation) and external auditing corporations. To avoid the shock of the Asian financial crisis in 1997, which had a heavy impact on economic change, the research selected 1,080 manufacturing firms (KSIC code=10~33) that were less than 4 years old from their establishment in since 1997. According to the industry categorization standards of OECD for manufacturing, the firms were divided into high-tech industry and low-tech industry and the results of firms were compared.

As for dependent variables, the sales growth rates of firms were used in the form of natural logarithmic functions. The sales growth rates were divided into short-term (less than 4 years old) and long-term (between 7~10 years old). The financial variables of firms were adjusted based on 2005 by utilizing GDP deflator to avoid the impact of annual macro-economic changes. The main independent variables, pre-entry experience and post-entry effort, used the dummy variables to distinguish the existence of experience and the interaction variables between two experience dummy variables.

As for pre-entry experience, the firms with the characteristics of *de alio* have 1 for variable pr and the firms with those of *de novo* have 0 for variable pr. The research assumed that if a new firm belongs to a corporate group, it has characteristics of *de alio* and can receive the R&Cs from its parent company, and if not, it has characteristics of *de novo*, that is, a new business with its own R&Cs.

As for post-entry effort, the effects were analyzed by looking at the growth rate of tangible assets, the growth rate of R&D intensity and the growth rate of employees. If each growth rate is higher than the average growth rate of firms in the same industry, the research considers that the strength of post-entry effort caused by the post-entry activity is high and when the strength is high, the dummy variables (po_ass, po_rnd, po_emp) become 1. That is, the firm with high growth rate of tangible assets has 1 as variable po_ass; otherwise, it has 0 as variable po_ass. The same method was applied to variable po_rnd representing R&D intensity growth rate and variable po_emp representing the growth rate of employees (human resources).

The duration of the post-entry effort was limited to 4 years after the firm's establishment and the increase/decrease of experience was calculated on average.

In order to measure the short and long-term result of a firm, a dummy variable (t) was used to represent the period. For short-term (4 years or less), the variable t is 0 and for the long-term, of a firm between 7 and 10 years old, variable t is 1.

The research analyzed the impacts of pre-entry experience and post-entry effort on the sales growth rates of firms for both short-term and long-term, and at the same time, to analyze the results of the two experiences' mutual operations the research studied pre-entry experience, post-entry effort, three dummy variables representing terms, and other dummy variables of crossed items. To measure pre-entry experience, post-entry effort, and coefficient values of three main dummy variables related to period and statistical significance, the analysis used the model of triple difference (difference in difference in difference).

Triple difference has the advantage of verifying the significance of not only of the coefficient values ($\beta1$~$\beta3$) of three main dummy variables, but also the coefficient values ($\beta4$~$\beta7$) of the respective interaction dummy variables as given in equation 14. The interaction variables (pr x po_ass, pr x po_rnd or pr x po_emp) of pre-entry experience and post-entry effort are independent variables and they function as important control variables necessary to determine whether the factors influencing growth of firms are inherited R&Cs or nurtured R&Cs. Natural logarithm value of the sales of the applicable previous year was used as controlled variants of the firm size, and R&D investment for the previous year were used as control variables.

The result of the Hausman test confirmed the endogeneity between the main independent variables and error terms. To solve this, regression analysis was conducted with a model of Hausman and Taylor which enabled the gain of a consistent estimator from the panel data (Hausman and Taylor, 1981). In this type of research where a dummy variable is a main independent variable, this model is useful as it identifies the coefficients of dummy variables that are omitted in the analysis with the fixed effect model and verifies their significance.

The equations of the main d in d in d (triple difference) models are as follows (inferior letter i: firm, t: time):

$$y_{it} = \beta_0 z_{it} + \beta_1 pr_i + \beta_2 po_i + \beta_3 t \qquad \text{Eq. (14)}$$
$$+\beta_4 (pr \cdot t)_{it} + \beta_5 (po \cdot t)_{it} + \beta_6 (pr \cdot po)_i + \beta_7 (pr \cdot po \cdot t)_{it} + \varepsilon_{it}$$

y_{it}	: firm's sales growth rate
pr_i	: pre-entry experience or not
po_i	: post-entry effort or not
	(degree of experience for 4 years after the establishment)
t	: long-term result of sales growth rate or not
z_{it}	: other control variables – firm size, sales , tangible assets, etc.
$(pr \cdot t)_{it}$	: interaction variables of variable pr and variable t
$(po \cdot t)_{it}$	: interaction variables of variable po and variable t
$(pr \cdot po)_i$	: interaction variables of variable pr and variable po
$(pr \cdot po \cdot t)_{it}$	: interaction variables of variable pr, variable po and variable t

In the model of Eq. (14), depending on the type of post-entry effort, po_ass, po_rnd, or po_emp was used. Table 15 explains the variables used in this research.

Table 15. Definition of variables in post-entry effort studies

Key variables	Definition
y	Firm's sales growth rate, $y_{it}= \ln S_t - \ln S_{t-1}$, ($S_t$: sales of the applicable year, S_{t-1}: sales of the previous year)
pr	Pre-entry experience or not (*de alio* or *de novo*) – 1 for a firm affiliated with a corporate group and 0 for others
po_ass	1 if the average growth rate of the tangible asset for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
po_rnd	1 if the average growth rate of R&D intensity for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
po_emp	1 if the average growth rate of human resources for the first 4 years after establishment is higher than the average growth rate of the same industry, and 0 if not.
t	For the first 4 years after establishment t=0 (short-term), between 7 years and 10 years t=1 (long-term).
pr x t	Interaction dummy variable of variable pr and variable t
po_ass x t, (po_rnd x t, po_emp x t)	Interaction dummy variable of variable po_ass and variable t (the same method is applied to variable po_rnd and variable po_emp)
pr x po_ass, (pr x po_rnd, pr x po_emp)	Interaction dummy variable of variable pr and variable po_ass (the same method is applied to variable po_rnd and variable po_emp)
pr x po_ass x t, (pr x po_rnd x t, pr x po_emp x t)	Interaction dummy variable of variable pr, variable po_ass and variable t (the same method is applied to variable po_rnd and variable po_emp)
L.ln_sales	Natural logarithm value of the sales of the applicable previous year (applying GDP deflator)
L. rnd_int	R&D intensity value of the previous year

5.4 Empirical analysis

5.4.1 Results of descriptive statistical analysis

Empirical was conducted on Korean manufacturing firms established between 1997 and 2000. By using the unbalanced panel data activities of 1,080 firms (3,063 for the number of observed targets) between 1997 and 2009, the research conducted regression analysis.

Table 16 shows the number of observed targets and the total ratio in order to figure out the ratio between pre-entry experience and post-entry effort. As is evident from Table 16, *de novo*, without pre-entry experience shows more number of observed targets, (about 1.6 times) than *de alio*. Additionally, new firms, regardless of pre-entry experience, show intense R&D activities and employees' post-entry effort, and a comparison of the numbers of observed targets verified that the investment was not very active in the case of tangible assets. Overall, while *de novo* shows on average 1.6 times more observed targets than *de alio*, post-entry effort of tangible assets shows twice the number of observed targets. It proves that right after the establishment *de novo* extends tangible assets more than *de alio*.

Table 17 shows that for post-entry effort of tangible assets, the number of observed targets, average value, the correlation matrix equivalent to standard deviation for main variables and main dummy variables, and the overall ratios can be verified through the mean value and the same number was shown in Table 16.

Except for the correlation between the firm size and the interaction variables, it was verified that the crossed correlation among variables is not very high and other post-entry efforts showed values similar to those of tangible assets.

Table 16. The number of observed targets and total ratio of pre-entry experience and post-entry effort

Pre-entry experience	Post-entry effort						
	Tangible assets		R&D intensity		Employee		
	Weak	Strong	Weak	Strong	Weak	Strong	Total
De novo	1,278	627	733	1,172	728	1,177	1,905
	(41.7)	(20.5)	(23.9)	(38.3)	(23.8)	(38.4)	(62.2)
De alio	831	327	460	698	454	704	1,158
	(27.1)	(10.7)	(15.0)	(22.8)	(14.8)	(23.0)	(37.8)
Total	2,109	954	1,193	1,870	1,182	1,881	3,063
	(68.9)	(31.2)	(39.0)	(61.1)	(38.6)	(61.4)	(100.0)

Frequency percentage in parentheses

Table 17. Descriptive statistics for variables in post-entry effort studies

		Obs.	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	y	3063	0.129	0.397	1.000									
2.	L.ln_sales	3063	16.571	1.428	-0.292	1.000								
3.	L.ln_rnd	3063	12.780	1.760	-0.053	0.371	1.000							
4.	pr	3063	0.378	0.485	-0.031	0.274	0.175	1.000						
5.	po_ass	3063	0.311	0.463	0.024	-0.058	-0.017	-0.049	1.000					
6.	t	3063	0.810	0.393	-0.209	0.342	0.166	0.011	-0.008	1.000				
7.	pr x t	3063	0.308	0.462	-0.101	0.332	0.194	0.856	-0.043	0.324	1.000			
8.	po_ass x t	3063	0.251	0.434	-0.059	0.065	0.049	-0.038	0.860	0.281	0.048	1.000		
9.	pr x po_ass	3063	0.107	0.309	-0.021	0.075	0.083	0.443	0.514	0.003	0.378	0.449	1.000	
10.	pr x po_ass x t	3063	0.087	0.282	-0.075	0.136	0.106	0.396	0.459	0.150	0.462	0.533	0.892	1.000

5.4.2 **Results of regression analysis**

Tables 18–20 show the regression analysis results for each type of post-entry effort. Overall, as the size of a firm is less, the growth rate of sales rises.

As known from the basic model of Model (1), the growth rate of sales was positively impacted by the pre-entry experience. However, when the growth rate of tangible assets was high, there was no significant impact on the growth rate of sales, as in the case of firms with strong post-entry effort.

The extended Models (2)–(4) show the analyses results with the addition of interaction variables as control variables. For the pre-entry experience, the long-term growth rate cannot be verified for the statistical significance level (variable pr x t) except for the low-tech. That is, it is difficult to decide whether inherited R&Cs are useful for the growth of long-term sales.

For pre-entry experience with strong post-entry effort (variable pr x po_ass), that is, if the firms with large inherited R&Cs increase their nurtured tangible assets intensely, there is a negative insignificant impact on the growth rate of sales. The caution is that, in this case, the post-entry effort of *de alio* firms gives a negative insignificant impact on the growth rate of long-term sales (variable pr x po_ass x t) in Model (2) and Model (3). It is estimated that since tangible assets are machines, facilities, devices, and so on, resourceful *de alio* firms can easily secure these. Therefore, tangible assets whose sizes become bigger turn into obstacles to environmental changes and interfere with the firm's growth rate, especially in high-tech industry.

Table 19 shows the effects of post-entry effort of R&D intensity.

Model (5) shows that a *de alio* firm's sales growth rate is positively impacted, and the extended models (Models (6)–(8)) controlling crossed variables show the same result. Firms with strong R&D intensity in post-entry effort witness a negative impact on the growth rate of sales. In the analysis of adding crossed variables as control variables, like Model (6) and Model (7), it is verified that higher increasing of R&D intensity post-entry effort decreases the growth rate of sales (variable po_rnd). However, from a long-term perspective, as the negative value changes to positive, it boosts growth rate of sales (variable po_rnd x t). This result showed a significantly meaningful result of confirming the fact that post-entry efforts showed effects that differed between short-term results and long-term results.

R&D intensity is a representative intangible asset, and it creates a new long-term alternative for the innovation and evolutionary development of a firm. Therefore, as March (1991) explains, the evolutionary development of a firm is dependent on the concepts of local exploitation and extensive exploration. The research similarly shows that R&D activities do not provide good causes for the short-term effects, but do provide positive causes for the long-term effects, such as extensive exploration.

Finally, Table 20 shows the result of employees' post-entry effort.

Model (10) shows that the firms with strong human resources in post-entry effort demonstrate high growth rate of sales (variable po_emp). This verifies that human resources in post-entry effort is effective in raising the short-term growth rate of sales, which is changed to the negative effect on the long-term results (variable po_emp x t). This result shows the opposite result to that of R&D intensity in post-entry effort. This demonstrates that the effects vary depending on the type of post-entry effort.

Model (10) and Model (11) show that significant results could be retrieved on the common effects of pre-entry and post-entry efforts in the short-term growth rate of sales. In the analysis of adding crossed variables as control variables, like Model (10) and Model (11), it is verified that higher increasing of employee's post-entry effort of a *de alio* firm decreases the growth rate of sales (variable pr x po_emp). However, from a long-term perspective, as the negative value changes to insignificant positive, it means that effect of a *de alio* firm's post-entry effort disappears in the long-term (variable pr x po_emp x t).

Employee (human resources) is used as a variable to measure the size or growth of a firm, sales and total assets, and innovation. Innovations are theoretically categorized into product innovation and process innovation, wherein product innovation requires more employees and process innovation reduces the number of employees due to enhancement of productivity. However, the empirical studies show mixed results in terms of the relation between innovation and employment growth (Evangelista and Savona, 2003; Hall et al., 2008).

The research considered the variable employee as a concept of input mixed with tangible assets and R&D intensity and conducted an empirical analysis on the effects of its output, the growth rate of sales. As known from the result, the effect of employee's post-entry effort on sales growth is different from that of R&D intensity in post-entry effort. Additionally, when firms respond to market situations initially and expand the employee base (human resources), the new employees might adapt to the new environment, and this can support the firms' growth in the short-term.

As for tangible assets, post-entry effort shows significant value only in the low-tech industry, and in the long term, it shows a negative impact on the growth rate of sales. As for employee post-entry effort, it shows a negative impact on the long-term growth rate of sales, and only R&D activities in high-tech have a positive impact in the long term.

The long-term effect of R&D post-entry effort showing significant results in regression analysis is clearly demonstrated in the high-tech industry. This is because high-tech industries are exposed to a more abruptly changing environment and intellectual assets are required. Thus, post-entry effort is a very important factor for their growth. This result demonstrates that structural inertia is created from the initial experience of a new firm and, therefore, it is important to build good structural inertia early and the long-term effects vary depending on the type of industry and the type of entry experience.

Table 18. Regression results according to tangible assets- based efforts

	Model (1)	Model (2)	Model (3)	Model (4)
VARIABLES	Baseline of Tangible assets	Overall in Manufacturing.	High-tech. in Manufacturing	Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.266***	-0.261***	-0.301***
	(0.013)	(0.013)	(0.015)	(0.030)
L.ln_rnd	0.002	0.004	-0.001	0.016
	(0.008)	(0.008)	(0.010)	(0.011)
t	0.121***	0.136***	0.109***	0.263***
	(0.024)	(0.032)	(0.038)	(0.053)
pr	0.201***	0.265***	0.211***	0.474***
	(0.030)	(0.049)	(0.058)	(0.089)
pr x t		-0.048	-0.005	-0.213***
		(0.042)	(0.051)	(0.065)
po_ass	-0.004	0.040	-0.003	0.202**
	(0.029)	(0.050)	(0.060)	(0.085)
po_ass x t		-0.008	0.053	-0.230***
		(0.045)	(0.055)	(0.068)
pr x po_ass		-0.067	-0.023	-0.169
		(0.084)	(0.099)	(0.159)
pr x po_ass x t		-0.053	-0.113	0.122
		(0.075)	(0.089)	(0.123)
Constant	4.405***	4.262***	4.261***	4.609***
	(0.204)	(0.206)	(0.237)	(0.468)
Wald chi2 (d.f.)	602.39 (5)	602.88 (9)	474.97 (9)	131.36 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 19. Regression results according to R&D intensity- based efforts

VARIABLES	Model (5) Baseline of R&D intensity	Model (6) Overall in Manufacturing.	Model (7) High-tech. in Manufacturing	Model (8) Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.263***	-0.257***	-0.310***
	(0.013)	(0.013)	(0.015)	(0.032)
L.ln_rnd	0.003	-0.004	-0.011	0.010
	(0.008)	(0.008)	(0.011)	(0.011)
t	0.121***	0.081**	0.066	0.163***
	(0.024)	(0.035)	(0.042)	(0.062)
pr	0.200***	0.269***	0.247***	0.404***
	(0.029)	(0.056)	(0.065)	(0.118)
pr x t		-0.078*	-0.065	-0.139*
		(0.046)	(0.055)	(0.076)
po_rnd	-0.020	-0.128***	-0.128**	-0.136
	(0.028)	(0.049)	(0.060)	(0.087)
po_rnd x t		0.137***	0.156***	0.064
		(0.044)	(0.054)	(0.070)
pr x po_rnd		-0.041	-0.081	0.037
		(0.078)	(0.093)	(0.144)
pr x po_rnd x t		0.035	0.063	-0.029
		(0.069)	(0.084)	(0.109)
Constant	4.405***	4.370***	4.368***	4.959***
	(0.205)	(0.200)	(0.228)	(0.494)
Wald chi2 (d.f.)	603.46 (5)	646.73 (9)	515.43 (9)	124.85 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 20. Regression results according to employee-based efforts

VARIABLES	Model (9) Baseline of Employee	Model (10) Overall in Manufacturing.	Model (11) High-tech. in Manufacturing	Model (12) Low-tech. in Manufacturing
L.ln_sales	-0.271***	-0.265***	-0.259***	-0.299***
	(0.013)	(0.013)	(0.015)	(0.031)
L.ln_rnd	0.002	0.007	0.000	0.017
	(0.008)	(0.008)	(0.010)	(0.011)
t	0.121***	0.177***	0.168***	0.240***
	(0.024)	(0.039)	(0.045)	(0.070)
pr	0.201***	0.339***	0.323***	0.458***
	(0.030)	(0.064)	(0.073)	(0.134)
pr x t		-0.070	-0.069	-0.097
		(0.054)	(0.063)	(0.093)
po_emp	-0.004	0.113**	0.119**	0.109
	(0.027)	(0.049)	(0.058)	(0.093)
po_emp x t		-0.080*	-0.076	-0.113
		(0.045)	(0.054)	(0.075)
pr x po_emp		-0.159**	-0.202**	-0.087
		(0.079)	(0.093)	(0.150)
pr x po_emp x t		0.011	0.049	-0.080
		(0.070)	(0.084)	(0.114)
Constant	4.406***	4.158***	4.155***	4.588***
	(0.206)	(0.208)	(0.240)	(0.477)
Wald chi2 (d.f.)	606.06 (5)	611.95 (9)	479.38 (9)	127.36 (9)
Observations	3,063	3,063	2,345	718
Number of firm	1,080	1,080	794	286

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.5 Summary

The result of the empirical analysis demonstrates that pre-entry experience and post-entry effort have various impacts on the growth of firms. This research provides important clues in understanding whether the R&Cs that lead to growth of firms are derived from the pre-entry or post-entry effort.

The validities of natural R&Cs disappear as time goes by. This satisfies hypothesis 1, which states that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate. Inherited R&Cs can be effective on short-term results; however, as time goes by and environmental changes occur, the firms dependent only on inherited R&Cs do not eventually adapt to these changes and consequently generate insufficient result in the long-term. This result is similar to the organization ecology perspective in which firms not able to adapt to the environment perish.

On the other hand, nurtured R&Cs do not lose their validity and have long-term impacts on the firm. This confirms hypothesis 2a, which states that post-entry effort influences both short-term and long-term growth rates

This aligns with the evolutionary economy perspective in which the initial efforts of firms make the surrounding environment, and the structural inertia of organizations capable of adapting to the environment is re-built, and eventually, the firms adapt to the market actively. According to the non-/existence of pre-entry experience, the post-entry efforts show different impacts on short and long-term results. In high-tech industries, the discrepancy of this effect is obvious, because natural R&Cs gained from pre-entry experience are likely to be independent of the market or the competing environment, while nurtured R&Cs by post-entry effort are likely to be the ones that firms secure considering the market environment, competitors' activities, and firms' situations in the adapting process of evolution.

During the firms' adaption to the internal and external environments, the initial structural inertia is not changed easily; thus, the short-term result can be the opposite of the long-term result.

This research verified that, depending on the type of the nurtured experience, local short-term effects and extensive long-term effects are differently generated. March's argument (1991) that parallel implementation of exploitation and exploration is the most effective way is yet be verified; nevertheless, it is understood that nurtured R&Cs enable firms to evolve by directing various experiences in parallel.

In the case of R&D intensity and human resources, the long term effects from their mutual operation of pre-entry experience and post-entry effort were not significant on the growth of firms; thus, it is understood that each experience is independent, and the effect is generated when they mutually operate.

The present research is a novel trial, differentiated from other existing researches in that it divided the R&Cs that were believed to be the original power of the firm's growth into the inherited, natural ones before the entry and the raised, nurtured ones after the entry and verified whether each had an effect on the long-term growth of a firm through empirical analysis. By verifying that the initial entry experience causes structural inertia, which consequently impacts the future growth of a firm, the research conducted a dynamic trace on the conventional argument from the resource-based perspective and the evolutionary economics theory that the initial entry experience is an important factor. This demonstrates that this research has an academic significance concerning the dynamics of firms.

The result of the research suggests that firms' management executives consider strategic decisions that firmly delineate the pre-entry experience and post-entry effort of new firms.

Additionally, in the beginning of the business, good structural inertia strategy is more important than extending the firm's size. The research also provides a logical argument to the policy-makers such that, because the incubation period when firms can experience trials and errors is very important, governmental financial and institutional support should be strategically designed to augment the future growth of firms by facilitating the nurture of post-entry R&Cs.

Chapter 6. Conclusions and implications

The present research sought to clarify factors affecting firm growth with regard to R&Cs. Specifically, this thesis focused on two classes of R&Cs (pre-entry and post-entry) that influence firms' growth prospects. The relationship between the state of firms upon market entry and the future growth of firms was also analyzed.

6.1 Conclusions of inherited (natural) resources and capabilities

The results of the effects on the R&Cs are studied through the *de alio* and *de novo* categorization of market entrants. It has been expected that, on average, *de alio* firms tend to have a larger sales-size than *de novo* firms, and *de novo* firms have a higher R&D intensity than *de alio* firms. In addition, this research has confirmed that *de alio* firms enter the market with higher levels of R&Cs due to the pre-entry experience, and *de novo* firms have a higher potential of technology innovation. Moreover, it has been also shown that, in reality, *de novo* invests more in R&D.

In terms of the firm's growth, *de alio* firms with the sufficient R&Cs have higher growth rates than *de novo* firms do, which is similar to the findings of previous related studies. However, the important focus of this research was to determine whether, how long, and to what extent this phenomenon continues. As a result, it demonstrates that the gap of characteristics between *de alio* and *de novo* firms decreases over time. After a certain period of time, a *de alio* firm with the pre-entry experience does not continue to have the same growth rate, which means that as the time passes, the inherited R&Cs do not significantly affect the firm's growth. Specifically, it was found that four years after market entry, the gap of sales growth rate between *de alio* and *de novo* firms is concretely decreased.

In the organization ecology perspective, a *de alio* firm, with the sufficient natural R&Cs inherited from the pre-entry experience, is more likely to be selected by the initial environment. As a result, the short-term growth rate is high. However, the natural R&Cs received from the parent firm have positive impacts on the growth and survival of firms in the beginning of the business.

However, of course, the firm should continue to undertake effort to obtain distinctive R&Cs, as no R&Cs can last forever. These kinds of effort are called the post-entry efforts for adapting to in environment according to the "Variation–Selection–Retention–Competition" process of the evolutionary economics perspective.

6.2 A comparison of the resources and capabilities

The firm's R&Cs created by pre-entry experience and post-entry effort, and their effects on firms' growth are summarized below:

First, R&Cs that lead to the firm’s growth are generated through both pre-entry experience and post-entry effort. However, the effects of the pre-entry experience decline as time passes. Therefore, the effects of pre-entry experience are more conspicuous on the short-term growth rate than those on the long-term growth rate. This demonstrates that natural R&Cs can affect the short-term performance of the firm. However, the firms that just depend on natural R&Cs might fail to respond to environment changes in a timely manner, and it also leads to the failure of their long-term performance. From the organization ecology perspective, the firms that are not appropriate to the environment become extinct. This states that pre-entry experience is more effective on the short-term growth rate than on the long-term growth rate.

Second, the effects of post-entry experience have an impact on a firm’s long-term performance. This confirms that the nurtured R&Cs do not lose their validity and do have an impact on the firm’s long-term performance. Moreover, the nurtured R&Cs have an impact on a firm’s short-term performance in the firm’s initial stage of adapting to the environment. At the same time, the structural inertia generated during the adaptation process becomes routine, and it also has an impact on a firm’s long-term performance. This proves that post-entry effort influences both the short-term and long-term growth rates. Therefore, the evolutionary economics with the perspective of active adaptation to the market and the resource-based view provide the same interpretation.

Third, this research has confirmed that the result of nurtured R&Cs are accumulated from different efforts, and each of has a different impact on the firm's short-term and long-term performances. Depending on the type of R&Cs, some are favorable for the short-term performance but unfavorable for the long-term performance, and vice versa. Most R&D activities are unfavorable for the short-term performance but favorable for the long-term performance. However, the efforts for increasing human resources have opposite results. These patterns are particularly obvious in the high-tech industry. Unlike the natural R&Cs that are inherited regardless of the market or competition environment, the nurtured R&Cs are created by post-entry efforts. This effort is accumulated as the firms experience the market environment, competitors' trends, and various challenges. These are larger in the high-tech industry, which undergoes severe environmental changes and competition. Generally, R&D activities should be invested for their long-term effects rather than their short-term effects.

However, increasing human resources for the sake of short-term performance will hinder the development of the adequate human resources while the environment changes and existing human resources become an obstacle due to the structural inertia that hampers adaptation in the long-term.

During the firms' adaptation to internal and external environments, the initial structural inertia does not easily change and, thus, the short-term result can be the opposite of the long-term result.

This research verifies that, depending on the type of nurtured experience, local short-term effects and extensive long-term effects are generated.

6.3 Implications

This research is a novel trial and can be differentiated from previous studies, in that it categorizes the R&Cs that were believed to be the original source of a firm's growth into inherited "natural" ones before entry and cultivated "nurtured" ones after entry. Moreover, empirical analysis was employed to verify whether each had an effect on the long-term growth of a firm. In particular, by verifying that the initial entry experience causes structural inertia, this research is a dynamic investigation of the conventional argument found in the resource-based perspective and the evolutionary economics theory. The structural inertia has a consequent impact on the future growth of a firm, and the initial entry experience of a firm is an important factor. This demonstrates that this research is of academic significance to the literature on firm dynamics.

As shown in the result of the research, there are different capabilities favorable for short-term performance and long-term performance. Depending on the firm's focus, the long-term performance can be different in terms of the specific firm's financial result. It provides an important strategic implication in addition to March's exploration/exploitation theory. That is, the development of a firm's R&Cs should be continued considering a long-term perspective, despite side-effects in the beginning.

The result of this research proposes that firms' managers should consider a new business in terms of the various strategic decisions on the pre-entry experience and post-entry effort, and especially in the beginning of the business, the managers should be advised that establishing a good structural inertia is more important than extending the size of the firm.

In addition, this research proposes a logical principle to policy-makers. The incubation period is crucial since the firms can experience trial and error during that period. Therefore, governmental support for new firms should be strategically offered to augment future growth.

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Appendix 1: Estimation result of the quantile regression model

Estimation result of the quantile regression model (≤ 3rd year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Estimation result of the quantile regression model (4^{th}~6^{th} year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Estimation result of the quantile regression model (≥7th year)

VARIABLES	q10	q20	q30	q40	q50	q60	q70	q80	q90
de_novo	-2.156***	-1.994***	-2.645***	-3.362***	-3.980***	-4.733***	-4.989***	-6.025***	-6.445***
	(0.499)	(0.680)	(0.943)	(0.854)	(0.461)	(0.365)	(0.723)	(0.750)	(1.962)
d_subsector	0.319*	0.202**	0.210*	0.286**	0.318**	0.291	0.246	0.358*	0.537**
	(0.172)	(0.102)	(0.117)	(0.142)	(0.127)	(0.177)	(0.164)	(0.187)	(0.237)
de_novo x ln_sales	0.247***	0.219***	0.288***	0.356***	0.392***	0.462***	0.476***	0.554***	0.544***
	(0.048)	(0.071)	(0.098)	(0.091)	(0.049)	(0.039)	(0.066)	(0.071)	(0.157)
age	-0.077	0.015	-0.075	-0.121	-0.018	-0.042	0.018	-0.200	-0.096
	(0.117)	(0.088)	(0.107)	(0.095)	(0.087)	(0.116)	(0.161)	(0.157)	(0.246)
profit/sales	0.019	0.022*	0.008	0.008	0.011**	0.007*	0.008**	0.009**	0.015**
	(0.013)	(0.011)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.004)	(0.007)
rnd_int (t-1)	0.048	0.045	0.040	0.036	0.058**	0.047**	0.038*	0.039*	0.015
	(0.033)	(0.030)	(0.037)	(0.034)	(0.027)	(0.022)	(0.021)	(0.020)	(0.025)
ln_sales	-0.105***	-0.117*	-0.200**	-0.294***	-0.340***	-0.367***	-0.414***	-0.479***	-0.640***
	(0.028)	(0.064)	(0.095)	(0.090)	(0.057)	(0.041)	(0.063)	(0.069)	(0.123)
constant	0.518	0.884	1.937**	3.034***	3.647***	4.224***	4.905***	6.149***	8.053***
	(0.330)	(0.647)	(0.922)	(0.815)	(0.535)	(0.483)	(0.755)	(0.734)	(1.491)
Pseudo R2	0.1873	0.1138	0.1076	0.1328	0.1817	0.2376	0.2988	0.378	0.4597
Observations	346	346	346	346	346	346	346	346	346

The significance is shown for two-tailed t-tests at the 99% (***), 95% (**), and 90% (*) significance levels

Abstract (Korean)

신생기업은 설립 이전의 경험(pre−entry experience)에 의해 전해지는 자원과 역량뿐만 아니라 설립 직후 여러 가지 경험(post−entry effort)에 의해 육성되는 자원과 역량에 의해서 성장해 나간다.

본 연구의 목적은 기업이 설립 직전 또는 설립 직후에 얻은 자원과 역량이 기업의 장기 성과에까지 영향을 미치는가를 파악하는 것이다. 이를 위해, 설립 이전의 경험(pre−entry experience)이 선천적(nature)으로 이어받는 자원과 역량(resources and capabilities)을 만들고, 설립 직후의 노력(post−entry effort)이 후천적(nurture)으로 육성 되는 자원과 역량(resources and capabilities)을 만들 것으로 판단하고, 설립 이전의 경험 유무와 설립 직후의 경험 강도를 측정하였다. 이와 같이 다른 종류의 경험이 기업의 성장경로에 미치는 효과를 보기 위해 기업의 성장률을 단기와 장기로 나눠서 동태적인 분석을 실시하였다.

우선, 선천적 경험의 효과를 확인하기 위해 디알리오(de alio) 및 디노보(de novo) 연구를 실시하였다. 선천적 경험의 효과를 극대화하기 위해서 신규산업인 신/재생에너지 산업을 대상으로 실증분석을 실시하였다. 선천적 경험이 있고 없음을 갖고 디알리오와 디노보로 구분할 수 있는데,

선천적 경험이 있는 디알리오가 매출 규모가 크고 단기 성장률이 높은 것으로 확인되었으며, 선천적 경험이 없는 디노보는 R&D 집적도가 높게 나는 것으로 확인되었다. 그러나 일정 기간이 지난 후에는 선천적 경험의 효과가 사라지면서 디알리오와 디노버의 특징이 없어짐을 확인하였다.

또한, 선천적 경험과 후천적 노력의 단기 및 장기 효과를 상호 비교하기 위해서 국내 제조산업을 대상으로 연구를 실시하였다. 단기 및 장기 효과를 비교한 실증분석 결과에서는 신생기업의 선천적 경험(pre-entry experience)보다는 후천적 경험(post-entry effort)이 장기 성장률에 더 강하게 영향을 미치고 있음을 확인하였다. 후천적 경험 중에서 R&D집중도는 High-tech. 산업에서 기업의 단기 성장률에는 부정적인 영향을 줄 수 있지만, 장기 성장률에는 긍정적인 영향을 주는 것으로 확인되었으며, 또 다른 후천적 경험인 인력자원(employee)의 증강은 이와는 반대로 전반적으로 장기적 성과에 부정적인 효과가 나타나는 것으로 분석되었다. 또한 선천적 경험은 전반적으로 기업의 장기 성장에는 영향을 못 주는 것으로 나타나며, 선천적 경험과 더불어 유형자산의 증가를 후천적으로 강하게 경험한 기업의 경우에는 Low-tech. 산업에서 장기 성장률에 영향을 미치되, 부정적인 효과를 보이는 것으로 확인되었다.

본 연구에서는 선천적 경험과 후천적 노력이 신생기업의 성장에 영향을 미치고 있으며, 선천적 경험의 효과는 시간이 지나면서 그 유효성이 점차

사라짐을 증명하였다. 반면, 후천적 노력의 효과는 기업의 장기 성과에도 영향을 계속해서 끼치는 현상을 밝힘으로써 기업 초기의 노력이 주변 환경과의 적응을 통해 조직의 루틴을 만들어가는데 매우 중요한 활동임을 보여주었다. 이는 사업 초기의 전략과 정책이 기업의 미래 성장을 결정지을 수 있다는 경영전략적 정책적 함의를 제공하는 중요한 연구성과가 될 것으로 기대한다.

주요어 : 선천적 경험, 후천적 경험, 기업 성장, 자원과 역량, 신생기업, 디알리오, 디노보

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